FACIAL EMOTION RECOGNITION IN REFUGEE CHILDREN WITH A HISTORY OF WAR TRAUMA

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ABSTRACT

Over 36 million children are currently displaced due to war, yet we know little about how these experiences of war and displacement affect their socio-emotional development – notably how they perceive facial expressions. Across three different experiments, we investigated the effects of war trauma exposure on facial emotion recognition in Syrian refugee (n=130, M_{age}=9.3 years, 63 female) and Jordanian non-refugee children (n=148, M_{age}=9.4 years, 66 female) living in Jordan (data collected 2019-2020). Children in the two groups differed in trauma exposure, but not on any of our measures of mental health. In Experiment 1, we measured children's biases to perceive an emotion using morphed facial expressions and found no evidence that biases differed between refugees and non-refugees. In Experiment 2, we adapted a novel perceptual scaling task that bypasses semantic knowledge, and again found no differences between the two group's discrimination of facial expressions. Finally, in Experiment 3, we recorded children's eye movements as they identified Middle Eastern actors' facial expressions, and again found no differences between the groups in either their identification accuracies or scanning strategies. Taken together, our results suggest that exposure to war-related trauma and displacement during early development, when reported by the caregiver but not always recollected by the child, does not appear to alter emotion recognition of facial expressions.

Keywords: emotion recognition, adversity, war trauma, refugee children

INTRODUCTION

Emotions help children navigate their environments and motivate many of their behaviours. The accurate identification of another's emotional states underlies healthy social development and allows children to detect possible threats and respond accordingly (Klinnert et al., 1986; Thompson, 2011). Arguably, one of the most important pieces of information for identifying another person's emotional state is their facial expression which plays a fundamental role in social communication and regulating interactions (Ekman, 1992; Martinez & Du, 2012). The ability to extract information about a person's emotional state from their expressions develops early in life (e.g., Leppänen & Nelson, 2008) when experiences - both positive and negative - can alter the trajectory of children's emotional development (e.g., Pollak, 2012; Zelazo & Carlson, 2012). As such, a number of emotional and behavioural problems, including dysfunctions in emotion regulation and altered emotion perception have been reported in children who experience early adversity (Harms et al., 2019), with atypical emotion perception often linked to psychiatric symptomatology which persists into adulthood (Berzenski, 2018; Gibb et al., 2009; Pollak, 2012).

Most research examining the link between emotion perception and early adversity has focussed on childhood abuse and neglect (Saarinen et al., 2021). Although more research is emerging, little is still known about the effects of other types of trauma on emotion perception, most notably trauma related to experiences of war. This is a substantive gap, given that more than 100 million people worldwide are forcibly displaced and the bulk of these are children (United Nations High Commissioner for Refugees [UNHCR], 2022). It is paramount to understand the effects of war on these vulnerable children's emotion processing to help develop an informed framework for addressing their mental health and wellbeing needs.

Emotion perception after early adversity

Atypical emotion recognition can be particularly detrimental to children's socio-emotional development, leading to dysfunctional emotion regulation and possible mental health issues (Harms et al., 2019). Impairments in children's ability to recognise and discriminate emotional expressions after adversity are well documented. For instance, Pollak et al. (2000) found that children who suffered physical abuse matched facial displays of *anger* to scenarios from vignettes indicating that they interpreted the protagonist of the scenarios as angry, whereas physically neglected children tended to match *sad* expressions to the same scenarios. Neglected children were also worse than controls at discriminating between pairs of facial expressions of anger, sadness, and fear (Pollak et al., 2000). In a later study, these authors found that abused children overidentified anger in facial expressions compared to controls, suggesting that abused children perceived more facial expressions as angry than sad or fearful (Pollak & Kistler, 2002). Physically abused children recognised anger earlier than non-abused children in a dynamic facial sequence, where the facial expression transitioned from being fully obscured to increasing in clarity (Pollak & Sinha, 2002).

The overall pattern emerging from these studies suggests that atypicalities in emotion recognition might depend on the type of adversity experienced. Early experiences of threat (such as physical abuse) result in enhanced perception of negative expressions mostly related to anger, whilst experiences of deprivation (such as physical neglect) tend to be linked to a general impairment in recognition of all emotions (Harms et al., 2019). One account of these impairments is that children with a history of early adversity might display an enhanced perception of sad and angry faces since they encounter them frequently in their environment (Pollak & Kistler, 2002). These biases in their perception might act as beneficial short-term adaptations, allowing children living in unstable environments to respond quickly to potential threats. However, if these perceptual biases persist, they could form detrimental patterns of

emotion processing, with negative consequences for children's socio-emotional development and mental wellbeing.

Investigating emotion perception in childhood

The majority of paradigms exploring emotion recognition rely on children's comprehension of emotional labels. The necessary conceptual, semantic, and linguistic demands of these tasks require children to use *emotion concepts* – personal, internal interpretations of how each emotion is defined (Nook & Somerville, 2019). However, how these emotion concepts are expressed through words can change throughout life (Nook & Somerville, 2019) and can affect emotion recognition accuracy in adults (Lindquist et al., 2006), suggesting that they are an important domain for the perception and expression of emotions. Although the basic words of emotions (e.g., *happy, angry*, etc.) are reportedly well understood from early childhood, as children's emotional lexicon increases, they gain additional emotion-descriptive words (Baron-Cohen et al., 2010), which might be more nuanced and not fit into the basic emotion labels. For example, a child might consider a facial expression to represent the protagonist feeling *sorry* or *hurt* rather than *sad*. This gradual development of emotional language can introduce an additional cognitive load during emotion perception, which could have an impact on different aspects of task performance. Children also tend to rely more on the valence than on the arousal domain of an emotion when presented with emotional words compared to adults, which can be linked to their developmental increase in verbal knowledge (Nook et al., 2017). The emotional lexicon increases throughout childhood until early adolescence (Nook et al., 2020) and research on facial emotion expressions suggests similar incremental learning trajectories for facial emotion recognition, with the adult-like conceptual categories of emotion representations emerging from 5 years of age (Woodard et al., 2021). The above suggests that measures of emotion identification which bypass the use of

conceptual knowledge and language would remove some of these limitations and improve our understanding of the perceptual components of emotion recognition in children. An exciting paradigm, developed in visual science, applied a difference scaling method (Maloney & Nam Yang, 2003) to extract the perceptual basis of colour discrimination and could be applied to facial expression discrimination / recognition tasks.

Another common method to examine how children may perceive emotional expressions is to measure how they look at different facial expressions using eye tracking: a precise, non-invasive, real-time measure of their eye movements (their scan paths) while they view a stimulus. When people look at faces, their fixations usually transition between the eyes and the mouth, as they are the most informative regions to convey information about emotions, intentions, and identity (Mehoudar et al., 2014). The eye region seems to be particularly important for emotion recognition (Schmidtmann et al., 2020), with children from about 3 years of age able to recognise expressions solely from the eye region of the faces (Franco et al., 2014). Scan paths tend to differ depending on the emotional valence of the face; people look at – and attend to - the mouth region more when the expression is positive whereas they look at - and attend to - the eye region more when the expression is negative (Rollins et al., 2021; Schurgin et al., 2014; Wells et al., 2016). Allocation of attention to different parts of the face also depends on individual characteristics, including personality, sex, age, and culture (Coutrot et al., 2016; Hu et al., 2014; Perlman et al., 2009; Proietti et al., 2015; Wheeler et al., 2011). Recent findings suggest that atypical scan paths might also be present in psychopathology, often characterised by either avoidance of, or increased attention to, the eye regions of emotional faces both in adults and children (Capriola-Hall et al., 2021; Coll et al., 2022). It is possible that atypical attention to faces might underlie dysfunctions in emotion identification (e.g., Adolphs, 2006). For instance, it may be that impaired emotion recognition may result, in

part, from atypical attention to relevant features in the face. Therefore, combining an emotion recognition paradigm with eye-tracking measures of attention could shed light on the cognitive processing involved in emotion perception.

Emotion processing and affective problems after exposure to war related trauma

The Syrian civil war, which began in 2011, is one of the worst modern humanitarian crises, leading to the displacement of almost 7 million Syrian refugees outside of Syria, with a further 7 million displaced internally (UNHCR, 2021a). Exposure to war-related trauma, displacement, as well as the continuous hardships following resettlement increase refugee children's risk for psychopathology, with reportedly high prevalence of symptoms of anxiety, depression, and PTSD (Hodes & Vostanis, 2018; Khamis, 2019). Recent work also suggests that both pre- and post-displacement adversity are strongly linked to psychosocial adjustment difficulties and emotional problems (Elsayed et al., 2019; Khamis, 2021; Veronese et al., 2021).

Emerging research indicates that emotion regulation and emotion perception in refugee youth might also be affected by their adverse experiences. Syrian children and adolescents who experienced more traumatic events showed higher levels of emotion dysregulation, with avoidant coping strategies associated with a greater number of PTSD symptoms (Khamis, 2019). Similarly, different emotion regulation strategies moderate the influence of traumatic experiences on both depressive and ADHD symptoms amongst North Korean refugee adolescents (Lee et al., 2020), and higher levels of PTSD symptoms were associated with deficits in affective working memory in Afghan refugee adolescents exposed to trauma (Mirabolfathi et al., 2020). In a recent study of Syrian refugee families, children and adolescents whose mothers reported higher PTSD symptoms were worse at recognising both sad and happy emotional expressions (Gredebäck et al., 2021). Surprisingly however, parental trauma exposure was not linked to their children's emotion recognition. Interestingly,

children's emotion recognition was associated with harsher parenting practices, which is more prevalent in younger and more socially isolated mothers in this sample, hinting at potential mechanisms behind atypical emotion processing in refugee context (Peltonen et al., 2022). In another study, Syrian refugee adolescents were presented with happy, angry, and surprised facial expressions and instructed to label them as either positive or negative (Mueller et al., 2021). The authors found that higher trauma exposure increased the likelihood of perceiving surprised expressions as negative, suggesting that the increased number of traumatic events might be linked to a negativity bias, leading children to perceive ambiguous emotions as negative. In line with these results, using a free viewing eye tracking task, we found that children who were exposed to more war- and displacement-related trauma spent longer looking at angry faces (Michalek et al., 2022). It is also important to highlight the complexity of emotion processing difficulties in children, and the abundance of factors that can influence them in the refugee context. Caregiver's mental health and parenting styles have been shown to affect children's emotion recognition (Gredebäck et al., 2012; Gredebäck et al., 2021; Peltonen et al., 2022), as well as children's more general socioemotional adjustment, functioning, and attachment (East et al., 2018; Eltanamly et al., 2021; Scharpf et al., 2021; van Ee et al., 2016). Furthermore, refugee children's adverse experiences are not limited to war exposure, but continue after resettlement and can include elements typical of deprivation, poverty, unstable family structure, isolation, and violence (Arakelyan & Ager, 2021; Panter-Brick et al., 2020; Reed et al., 2002), all of which may result in emotion processing atypicalities. However, the effects on emotion perception, specifically in refugee children, are not yet fully understood.

Overall, emotion dysregulation, poorer emotion recognition, increased attention to anger, and a general bias to perceive facial expressions as portraying a negative affect suggest potentially similar patterns of atypical emotion perception in refugee children, as compared to

other types of childhood adversity. However, *when* these atypicalities emerge and *how* they influence psychosocial functioning and mental health remains unclear.

The current studies

There are many reports that early adversity has significant effects on children's emotion recognition and mental health. However, less is known about how war- and displacement-related trauma – one of the increasingly common forms of adversity – influences emotion recognition and mental health for refugee children living in low- and middle-income countries. This is important because these children face multiple challenges. Understanding which mechanisms are affected by war trauma and might contribute to psychopathology would be beneficial to develop targeted interventions, to identify those most at risk, and isolate not only risk factors for emotional and behavioural problems but also potential protective factors to build resilience. Therefore, the aim of the current study is to provide a comprehensive overview of emotion recognition in refugee children with experiences of war-related trauma and displacement and evaluate how this relates to their mental health. To examine their emotion recognition skills comprehensively, we used three different types of tasks which target different factors. Firstly, we used a well-established emotion recognition task where facial expressions are morphed between two expressions in different ratios to create a range of expressions that vary in their ambiguity. This task allows us to measure if children have a particular tendency (a bias) to consistently perceive certain types of expressions (e.g., angry) in ambiguous facial expressions. Secondly, we adapted a maximum likelihood difference scaling (MLDS) model, which bypasses semantic labelling, to measure the extent to which perceptual factors underlying emotion recognition are altered by adversity. Finally, we used eye tracking to explore how children viewed different emotional expressions. In order to examine the emotion

recognition abilities of refugee children and link this to aspects of their mental health, we included a group of age matched non-refugee Jordanian children.

Experiment 1 (Emotion Recognition Bias Task)

We explored the association between war trauma, facial emotion recognition biases, and mental health outcomes in refugee children, using methodology previously validated in populations of children with a history of adversity (e.g., Pollak & Kistler, 2002). Based on previous research findings presented above we hypothesised that 1) refugee children would be biased to perceive ambiguous faces as sad or angry along our morph dimensions compared to non-refugee children; and 2) that these emotion recognition biases would be positively correlated with children's trauma exposure and psychopathology.

Experiment 2 (MLDS Task)

Experiment 2 was similar to experiment 1 - exploring the relationship between war trauma, emotion recognition biases, and mental health outcomes in refugee children - but used methods that bypassed the need for emotion labels to provide a measure of mainly perceptual biases in emotion recognition. Similar to our hypotheses in Experiment 1, we expected that 1) refugee children would show an increased bias to perceive ambiguous faces as sad or angry along our morph dimensions compared to non-refugee children; and 2) emotion recognition biases would be positively correlated with trauma exposure and psychopathology.

Experiment 3 (Eye-Tracking Task)

The aim of experiment 3 was to measure facial expression recognition accuracy amongst refugee and non-refugee children whilst also measuring their eye movements to obtain

a proxy measure of their allocation of attention to the faces. At the time of this experiment, a culturally relevant database appeared and so we were able to use Middle Eastern actor faces. As this study was exploratory, we did not have specific hypotheses regarding the distribution of eye movements for different emotions, however, we hypothesised that refugee and non-refugee children would look differently at the emotional faces.

GENERAL METHODS

Ethics

The project was granted ethical approval from the [BLIND] research ethics board in 2018 (BLIND). Caregivers gave their informed consent prior to children taking part, either in person or via phone. Prior to the testing, we explained the task to children and asked if they were happy to take part. Children were also informed that they could stop at any time. They were given sweets and juice for participating; those tested in June 2019 at the Khadija Bint Khuwailed Community Centre and those tested in October 2019 and March 2020 at the Zaha Culture Centre were given 4JOD to cover travel costs.

Transparency and Openness

We report how we determined our sample size, all data exclusion (if any), all manipulations, and all measures in the study. The analyses code is publicly available on the OSF page (BLIND). Data were analysed using R (Core R Team, 2020) and JASP (Jasp Team, 2022), and can be provided on request. This study's design and its analyses were not pre-registered.

Participants

Participants ($N = 278$ in total) were Syrian refugee ($n = 130$; $M_{age} = 9.3$ years, $SD = 1.7$; 63 female, 61 male, missing gender data $n = 6$) and Jordanian non-refugee children ($n = 148$; $M_{age} = 9.4$ years, $SD = 1.7$; 66 female, 79 male, missing gender data $n = 3$) living in Amman, Jordan. Data collection took place at 5 different timepoints between February 2019 and March 2020, in different locations in Amman, including participants' homes, schools, and community centres. Information on testing location, numbers of participants, and tasks administered is presented separately for each point of data collection in Table S1. All experiments were run using Matlab (Mathworks) and Psychtoolbox (Brainard, 1997) on Dell laptop computers.

All participants were recruited through the non-profit organisation *Taghyeer* who offered a reading-based program to local children in Amman and liaised with schools and community centres to advertise the studies to local families (children tested at homes and community centres) and families of school children (children tested in schools). We aimed to ensure that our sample size was larger than that used to measure biases in emotion recognition in children after early adversity (e.g., Pollak & Kistler, 2002); however, the primary determinants of how many children we tested were resource/time constraints and the availability of the refugee participants. Children tested in February 2019 provided the baseline measurement of a longitudinal program evaluation of Taghyeer's shared book reading program, "We Love Reading" (Michalek et al., 2021).

TRAUMA AND PSYCHOPATHOLOGY

Methods

Trauma, PTSD symptoms, anxiety/depression symptoms, insecurity, distress, and optimism were measured with questionnaires originally developed in Arabic or adapted to Arabic. All questionnaires were administered by Arabic-speaking field workers using the Qualtrics Offline Application (Qualtrics, Provo, UT). Demographic information was collected

from the children, including age, gender, and family dependency ratio, prior to the questionnaire data. Dependency ratio was calculated as the number of household members without income divided by the number of household members with income and was used to assess household poverty. Children in all locations first completed the emotion recognition tasks (depending on the timepoint) and then all other self-reported questionnaire measures apart from trauma exposure questionnaire (which was caregiver-reported). The details of all the questionnaires are provided in the Supplemental Materials. To compare the questionnaire scores between refugee and non-refugee children, we used Bayesian independent samples t-tests. To explore the influence of trauma scores on mental health, we used Bayesian linear regression analysis with trauma as the predictor and PTSD symptoms, internalising problems, insecurity, or distress as outcomes (4 linear regression models).

Results

Demographic data, trauma and psychopathology scores for each group are presented in Table 1 and Figure S1. Refugee and non-refugee children were similar in age and levels of poverty (dependency ratio). As expected, using the Savage-Dickey approximation to compute the Bayes Factor, we found that refugee children experienced much more trauma than non-refugee children. However, refugee and non-refugee children who could recall at least one traumatic event did not differ in their PTSD symptoms score. There were also no group differences in internalising symptoms, insecurity, or distress scores, with the results suggesting the data are more likely under the null hypothesis. Bayesian linear regression analyses showed that the level of trauma exposure did not predict PTSD symptoms, internalising symptoms, insecurity, or distress (Table S2).

Table 1.

Demographics, trauma, psychopathology outcomes for refugee and non-refugee children

Measure		Refugees			Non-refugees			
	Range	*n*	*M*	SD	*n*	*M*	SD	*BF*
Age		130	9.27	1.71	148	9.43	1.70	0.20
Trauma	0-20	90	7.20	3.05	37	2.70	2.08	**2.41x10¹⁰**
PTSD	0-40	71	11.70	11.63	19	10.00	13.17	0.30
Anxiety/depression	21-63	115	27.56	6.16	132	26.56	5.40	0.33
Insecurity	10-40	106	21.75	6.16	133	21.53	6.60	0.15
Distress	10-48	115	18.36	5.71	140	17.30	4.97	0.45
Optimism	0-12	71	10.28	5.22	60	17.93	4.14	0.65
Dependency ratio	0-1	101	0.27	0.19	104	0.29	0.29	0.17

Trauma: TEC (caregiver report, measure of traumatic events child experienced), PTSD symptoms: CRIES, anxiety/depression (insecurity) symptoms: AYMHS, insecurity: HIS, distress: HDS, optimism: YLOT. BF_{10} = Bayes Factor in favour of the alternative hypothesis over the null hypothesis (Savage-Dickey approximation)

EXPERIMENT 1: EMOTION RECOGNITION BIAS TASK

Methods

Participants

Participants ($n = 134$) were Syrian refugee ($n = 71$; $M_{age} = 9.2$, $SD = 1.7$; 40 female) and Jordanian non-refugee children ($n = 63$; $M_{age} = 9.0$, $SD = 1.6$; 32 female). Data collection

took place at participants homes in Sweileh neighbourhood (refugees $n = 27$), Awael Al Khair Community Centre (refugees $n = 22$) and Shaqa'eq Al Nouman school (non-refugees $n = 20$) in Al Hashmi Al Shamali neighbourhood, Al Bonya school in Sahab neighbourhood (non-refugees $n = 25$) in February 2019; and in the Khadija Bint Khuwailed Community Centre in Sweileh in June 2019 (refugees $n = 22$, non-refugees $n = 18$).

Stimuli & procedure

The stimuli consisted of photographs of 4 actors (2 female and 2 male) displaying 5 different emotional expressions: fear, anger, happiness, neutral, and sadness. The photographs of 2 female and 2 male actors, taken from the Karolinska Directed Emotional Faces (KDEF) (Lundqvist et al., 1998), and the Radboud Faces Database (Langner et al., 2010). Photographs were cropped to include the face and remove most hair and accessories. For each identity (actor), we created facial morphs between two expressions creating two emotional dimensions using FantaMorph software (Abrosoft): happiness – sadness (HS) and fear – anger (FA). To create the emotional dimensions, emotional faces were morphed in steps of 10% with the neutral face, resulting in 21 facial morphs for each identity and dimension (Figure 1), with the neutral expression as the midpoint. On average, each image subtended 7.6 x 11.7 degrees and was displayed in colour in the middle of the screen, on a grey background.

Children were shown facial stimuli along the happiness – sadness (HS) and the fear – anger (FA) continuum and were asked to indicate which expression (out of the two forming the emotion dimension) each face displayed. Each trial began with a fixation point presented for 250ms, followed by the stimulus display, which remained on screen until a response was made. After each trial, a noise mask was presented for 250ms. The task was controlled with a Bayesian adaptive staircase (Watson & Pelli, 1983) and was comprised of 30 trials. Children were reminded they could only choose between the two emotions along the emotion dimension.

To minimise key press errors, children were asked to say their selection out loud in Arabic, and a fieldworker entered the answer into the computer. Each child was tested with the HS and FA stimuli in separate blocks, one block using the female actor and one using the male actor. The order of the blocks and block gender were counterbalanced across participants. For details on stimuli identities presented to the participating children at all timepoints, see the Supplementary Materials.

A
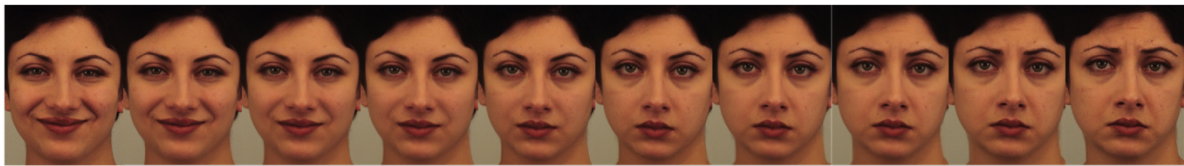
B

Figure 1. Sample morphed stimuli used in Experiments 1 and 2. (A) Female (KDEF: AF23HAS, AF23NES, AF23SAS; Lundqvist et al., 1998) and **(B)** Male faces (Radboud Faces Database; Langner et al., 2010) tested in February on the HS dimension. Note: for clarity, not all morph levels are displayed here.

Analysis

We took the distance between the point of subjective equality (PSE) - the morph level where the responses were 50% "sad" on the HS dimension (e.g., the face looked neither happy nor sad)- and the physical mid-point of the morph continuum (the neutral expression), as an index of bias. This was calculated separately for the HS and FA dimension using a Bayesian generalized linear multilevel model (GLMM) with the probit as link function. Differences between refugees and non-refugee children were given regularizing (centred on zero) Gaussian priors. We derived the prior for the difference in bias between refugees and non-refugees from Pollak and Kistler (2002), who reported differences between controls and physically abused children of about 29% of the morphing range in the conditions where they found a difference.

Our prior assigned 0.68 prior probability to the possibility that any difference in our data was less than 29% of the morphing range, and 0.95 prior probability to the possibility that the difference was less than 58%. This prior was used to estimate Bayes factors for group comparisons, using the Savage-Dickey density ratio method (Wagenmakers et al., 2010). The model was fit using Hamiltonial Monte Carlo (HMC) sampling as implemented in Stan (Carpenter et al., 2017) via its R interface. To assess the convergence of the model, we verified that there were no divergent transitions, and that potential scale reduction factor R-hat (Gelman & Rubin, 1992) was approximately 1 for all parameters. Finally, to investigate the relationship between emotion recognition biases, trauma, and mental health symptoms, we ran a series of Spearman's rank correlations.

Results

Emotion recognition was similar between refugees and non-refugees: both groups displayed less variability along the happiness-sadness (HS) continuum than the fear-anger (FA) continuum, and both groups displayed a bias for judging neutral faces as sad in the HS task (Figure 4). We found no evidence of a difference between refugees and non-refugees in their bias in either the HS task (difference between refugees minus non-refugees, expressed in % morphing: 0.4, 95%CI [-7.4, 8.5]) or in the FA task (difference: 1.0, 95%CI [-10.7, 13.7]). The Bayes factor suggested that the data were 14.28 and 9.38 times more likely under the null hypothesis of no difference in bias in the HS and FA tasks, respectively, providing strong evidence for a lack of difference in biases between refugee and non-refugee children. We also found no evidence of differences in the noise parameter (the standard deviation of the cumulative Gaussian psychometric function): the mean difference was 2.29, 95%CI [-3.42,8.49] in the HS task and was 8.2, 95%CI [-11.2, 27.6] in the FA task.

To explore relationships between emotion recognition and mental health and trauma measures, we calculated non-parametric correlations between bias and noise parameters and questionnaire scores (reported in Figures S4 and S5), however after correcting for multiple comparisons, none of the correlations remained significant (Bonferroni correction, all $p \geq .17$).
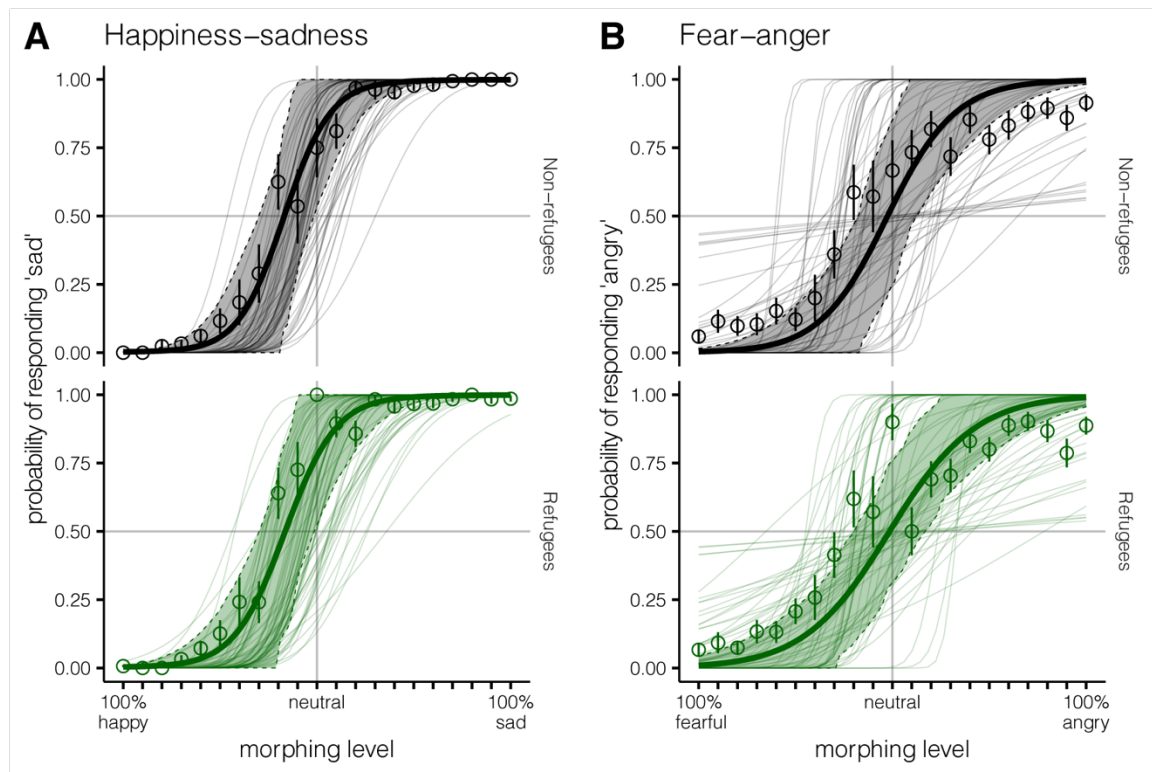
Figure 4. Emotion discrimination. Choice probabilities of response in the emotion discrimination task in the happiness-sadness (**A**) and fear-anger (**B**) continua. Dots are averages of individual responses, with standard errors; thin lines are individual psychometric functions, and the thick lines show group-level (fixed-effect) predictions with 95% HDI intervals. See Supplemental figures S2 and S3 for plots showing fits to individual data.

EXPERIMENT 2: MAXIMUM LIKELIHOOD DIFFERENCE SCALING (MLDS)

Methods

Participants

The experiment used facial stimuli either of the same actor (same-identity task) or of different actors (crossed-identity task, see Stimuli & Procedure below). 176 participants were

tested in the same-identity task, of those 85 were Syrian refugees (M_{age} = 9.6, SD = 1.8; 45 female) and 91 were Jordanian non-refugee children (M_{age} = 10.1, SD = 1.9; 49 female). Data from a first cohort of 49 children (28 refugees and 22 non-refugees) were collected in April 2019; a second cohort of 40 participants (22 refugees and 18 non-refugees) was tested in June 2019; and a final cohort of 87 participants (35 refugees and 52 non-refugees) was tested in March 2020. This last cohort was tested on the happy-sad continuum only. This was done because the early two cohorts displayed some evidence for a group difference in the variability of perceptual judgments that was independent of the emotion continuum and that did not affect the shape of perceptual scales, possibly suggesting larger perceptual noise in refugee children. We reasoned that this difference could have been due to differences in testing conditions: more refugees children were tested in private homes, with possibly more distractions, than in relatively more controlled environments such as schools or community centres (as suggested also by the larger fraction of errors in catch trials). To test this possibility more rigorously, in March 2020 we tested a larger sample of children in the Zaha Culture Centre on the happy-sad continuum only. Here we report the analyses on data collated across cohorts for each task; see the OSF repository (link provided for publication) for separate analyses for each cohort and analysis of errors in catch trials.

132 additional children were tested in the crossed-identity task in October 2019, consisting of 48 Syrian refugee (M_{age} = 9.4, SD = 1.7; 19 female) and 82 Jordanian non-refugee children (M_{age} = 9.7, SD = 1.7; 33 female).

Stimuli & procedure

We adapted a difference scaling method (Maloney & Nam Yang, 2003) to assess perceptual limits underlying emotion recognition of the facial expressions. The task involved comparing 3 faces (method of triads; Torgerson, 1958), arranged horizontally on the screen,

varying in levels of morphing (Figure 2). Children were asked to indicate whether the emotion expressed by the central face was more similar to the emotion expressed by the face on the left or to the emotion expressed by the face on the right. This can be reinterpreted as a comparison of differences (the participant is deciding whether the difference between the left and central faces is greater than, or less than, the difference between the central and right faces) and as such can be used to estimate an interval perceptual scale on the emotion continuum (Maloney & Nam Yang, 2003). We used 3 distinct tasks, each with different sets of stimuli: 2 same-identity tasks, in which all 3 faces presented on any given trial were from the same actor (Figure 2A and 2C), in one task morphed along the fear-anger and the other along the happiness-sadness continua; and one crossed-identity task, in which the central face and the lateral faces were from different actors (Figure 2B). The crossed-identity task was introduced to ensure that the results of the same-identity task were not due to children simply comparing local features or pixels, rather than employing a more holistic appraisal of emotional facial expression. In the crossed-identity task, all local features differ and judgments can only be based on a holistic appraisal.

Face stimuli were morphed (see SM) to create 9 levels along the emotion continuum, yielding 84 possible triplets (unordered combinations), and we presented each triplet to each participant once, with 12 additional catch trials resulting in 96 total trials (for the first cohort of children, there were 90 trials of which 6 were catch). Catch trials were interleaved with normal experimental trials and were implemented as triplets in which the two lateral faces corresponded to the unmorphed expressions (e.g., 100% happy and 100% sad) and the central face differed by only 10% morphing from either of the two. Each image subtended on average 8.1 x 10.6 degrees. Instructions to children were given during a brief initial guided practice session, which comprised of 5 catch trials. During the task, children were given the opportunity

of a break after every 30 trials. In order to keep them engaged, during the break they could win virtual golden coins for each catch trial that they answered correctly.
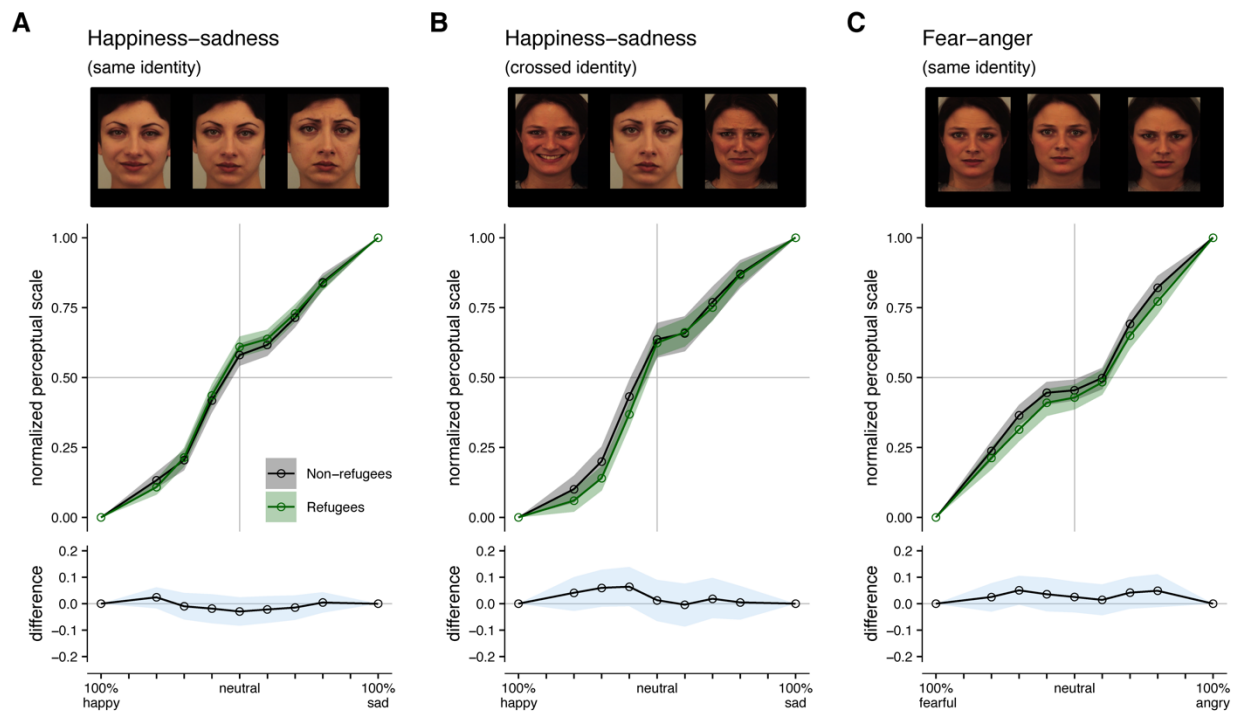
Figure 2. Perceptual factors underlying emotion recognition. Perceptual scales estimated using maximum-likelihood difference scaling (Maloney & Nam Yang, 2003). The scales were estimated at the group-level using a multilevel Bayesian approach. The top of each panel shows an example triples of stimuli. The normalized perceptual scales (representing how the perceived emotion intensity, plotted on the vertical axis, varies with the physical morphing, plotted on the horizontal axis) are shown in the middle. The lower sub-plot in each panel shows the difference (refugees minus non-refugees) in scale function values. All error bands represent 95% Bayesian HDI credible intervals. (KDEF images presented: AF23HAS, AF23NES, AF23SAS, AF20HAS, AF20SAS, AF20ANS, AF20NES, AF20AFS; Lundqvist et al., 1998)

Analysis

For each task, we estimated the perceptual scaling functions extending the maximum likelihood approach of Maloney and Nam Yang (2003) in a multilevel Bayesian framework. The model was fit using Stan (Carpenter et al., 2017) via its R interface; in all cases there were no divergent transitions and R-hat (Gelman & Rubin, 1992) was approximately 1 for all chains. The result of this analysis is a perceptual scale function which describes how the perceived

intensity of a facial emotion expression changes with the physical morphing of the image. The goal of this analysis is to identify specific features in the perceptual scales, such as biases (these would appear as the physical midpoint of the stimulus being perceptually closer to one of the two extremes) and possible categorical boundaries (these would appear as 'crispening', exaggerations of differences near a neutral point; see Maloney & Nam Yang, 2003), and investigate whether these differ between refugees and non-refugee children. To investigate the relationship between emotion recognition biases, trauma, and mental health symptoms, we ran a series of Spearman's rank correlations.

Results

The normalized perceptual scale functions for each experiment are shown in Figure 2. Overall, we find that the shape of the perceptual scale functions for refugee and non-refugee children were not significantly different across all conditions, indicating that the perceptual encoding of facial emotion expressions was very similar across the two groups. The shape of the functions did not provide evidence for a single, clear categorical boundary, but instead displayed in all cases a local decrease in steepness around the central neutral face. This may be due to the fact that stimuli were morphed from 3 initial images: the 2 emotions plus the neutral face, as such the neutral face may have been perceived as a separate category.

Interestingly, the shape of perceptual scales of the happiness-sadness (HS) continuum (Figure 2A and 2B) indicates that children perceived the neutral face as more similar to the sad face than to the happy face, thus mirroring the bias found in the emotion discrimination task in Experiment 1. The shape of the FA perceptual scale also showed a bias – that the neutral face was perceived as more similar to the fearful face than to the angry one – although the size of the bias is smaller than that for the happy-sad task.

Analysis of performance in catch trials did not reveal significant differences in both the HS, same-identity task (odds ratio 0.68, 95%CI [0.36, 1.25], $p = .22$) and the HS, crossed-identity task (odds ratio 0.67, 95%CI [0.42, 1.06], $p = .08$). However, we did find that refugee children were less frequently correct in catch trials in the FA task (odds ratio 0.52, 95%CI [0.27, 0.97], $p = .04$). This difference is likely due to testing conditions (see Participants section) and mirrors differences in judgment variability as reflected in the elevation of un-normalized scales (Figure S6). Importantly, despite the more frequent errors, the shape of refugee children's perceptual scale did not differ from that of non-refugee children (see Figure 2C), suggesting that their encoding of facial emotion expressions was also similar to non-refugees along the anger-fear continuum.

To explore relationships between emotion recognition and questionnaire measures, we calculated non-parametric correlations between bias and noise parameters and trauma and mental health scores (reported in Figures S7-S9). However, after correcting for multiple comparisons, none of the correlations remained significant (Bonferroni correction, all $p > .05$).

## EXPERIMENT 3: EYE-TRACKING TASK

Methods

Participants

Participants ($n = 128$) were 50 Syrian refugee ($M_{age} = 9.4$, $SD = 1.7$; 21 female) and 78 Jordanian non-refugee children ($M_{age} = 9.6$, $SD = 1.7$ 36 female). Data collection took place at the Zaha Culture Centre in Amman, in October 2019.

Stimuli & procedure

The stimuli consisted of 20 photographs of 4 Middle Eastern actors (2 male and 2 female) taken from the Iranian Emotional Face Database (Heydari et al., 2022). Each actor displayed 5 emotional expressions: anger, happiness, fear, neutral, and sadness. The stimuli were presented in their original colour on a green background using Matlab (Mathworks) and Psychtoolbox-3 (Brainard, 1997) routines on two Dell laptop computers. 75 participants completed the task on a 31 cm screen laptop with resolution 1366 x 768 and 53 participants on a 28 cm screen laptop with resolution 1920 x 1080. Participants sat approximately 55cm away from the screen and did not use a chin rest. All images were presented in colour in the centre of the screen and subtended approximately 12.3 x 21.5 degrees. Eye movements were recorded with a portable Tobii Eye Tracker 4C (sampling rate 90hz) mounted on the screen.

Prior to the task, the child's gaze was calibrated using a 9-point display that was repeated until deemed successful by visual inspection. Children were instructed to look at the images and stay as still as possible during the 'free-viewing' portions of the trial. The task of 20 trials immediately followed the calibration. Each trial started with a fixation point displayed centrally for 250 ms followed by the presentation of a single emotional facial expression for 2000ms, which was then extinguished (Figure 3). Immediately after viewing the emotional facial expression, children were presented with a choice of 5 emotions in Arabic and asked to choose which emotion corresponded to the facial expression (angry, fearful, happy, neutral, or sad). Options remained on screen until a response was given.-The presentation order of actors and emotional expressions were randomised over 20 trials
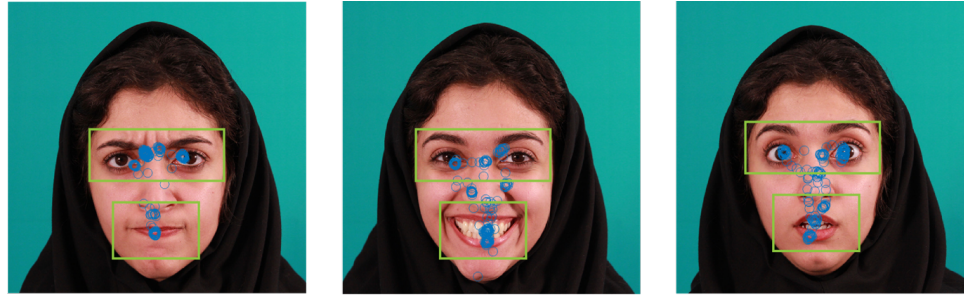
| Angry | Happy | Fearful |

Figure 3. Sample stimuli, with Areas of Interest (AOIs) and eye gaze samples superimposed. Example of three trials of different emotional expressions presented by the same actor (Emotional Face Database, Heydari et al., 2022). Gaze samples of 11ms (in blue) from 1 participant superimposed on the stimuli and AOI (in green) for illustrative purposes only.

Eye gaze processing

Two areas of interest (AOIs) were defined using Matlab by drawing rectangles around the left and right eyes, and the mouth for each emotional expression of each actor, separately for the two testing laptops. Data from different laptops was combined and data from AOIs for each emotional expression was pooled together and averaged across trials for each participant. Raw gaze data (*x* and *y* gaze positions) was categorised into fixations with a parsing algorithm (Nystrom & Holmqvist, 2010) and fixations were defined as stable gaze lasting at least 100ms within 1deg of visual angle. We calculated 3 main parameters: 1) *dwell*: the proportion of all fixations located within each AOI averaged across trials, 2) *first fixation*: the proportion of trials in which first fixation fell on each AOI separately for each emotion type, and 3) *fixation duration:* average duration of fixations on each AOI for each emotion type. The location of the fixation point presented during the inter-trial interval coincided with the location of the eye region for all stimuli. Therefore, to account for the possible effect of initial gaze on the fixation point, we excluded gaze immediately following stimulus onset (the first fixation-length gaze, on average 100ms) from the first fixation measure.

Trials with over 50% invalid samples (e.g., gaze not recorded by the eye tracker or falling outside of the laptop screen), and children with over 50% of invalid trials were excluded from the analysis ($n = 2$, non-refugees).

Analysis

To compare recognition accuracy for different emotions between refugee and non-refugee children we used the Bayesian multilevel logistic regression. Further, to test if eye gaze differed between refugee and non-refugee children, we conducted a 3-way Bayesian repeated measures ANOVA, with group as a between-subjects factor (2 levels: refugees, non-refugees), and emotion type (5 levels: anger, fear, happiness, neutral, sadness) and AOI (2 levels: eyes, mouth) as a repeated within-subjects measures. Statistical analyses were performed separately for each gaze parameter (dwell, first fixations, gaze duration). The main aim of these analyses was to determine whether attention allocation patterns differed between refugee and non-refugee children. We conducted a series of Spearman's ranked correlation to investigate the associations between the task outcomes and questionnaire scores.

Results

Emotion Recognition Accuracy

We used a Bayesian multilevel logistic regression with participants as random intercept and actor gender and emotion as predictors. The dependent variable (accuracy) is dichotomous (correct or incorrect). This model predicts the probability that a response made by the child to each emotional expression was correct. The Bayes Factor (BF) was calculated in *R* using bridge sampling with the package *brms* (Bürkner, 2017). We found that the data were 6.92 times more likely under the null hypothesis that there was no difference between the groups in identifying emotional expressions. For both refugee and non-refugee children response accuracy was

significantly higher compared to neutral faces only for happy (β=2.43, 95%Cl [2.01, 2.89]) and angry expressions (β=0.81, 95%Cl [0.51, 1.11]).

Eye tracking

Dwell

The Bayesian ANOVA results suggest that refugee and non-refugee children show similar sustained attention to emotional expressions. The data provided decisive evidence (BF > 100) for an interaction between *emotion* and *AOI*, confirming that visual exploration depended on the emotional expression. This interaction was found to be highly similar across the two groups, with the data providing strong support for the null hypothesis that dwell was not modulated by *group,* either as main effect or an interaction (all BF < 0.03; see Table S3 for a detailed report on Bayes factor results). Overall, the results indicate that dwell is affected the most by the interaction between *AOI* and *emotion,* whereas *group* (refugee v non-refugee) does not have an effect.

Post hoc analyses suggest that refugee and non-refugee children tend to dwell on the eyes the most when viewing angry faces and the least when viewing happy faces (Figure 5, Table S4). Correspondingly, dwell on the mouth was longest for happy and shortest for angry expressions.

First fixation

Refugee and non-refugee children showed similar distribution of first fixations. The data suggested (BF > 100) an interaction of *emotion* and *AOI*, confirming that the distribution of first fixations was modulated by the emotion of the actor. However, this interaction was highly similar across the refugee and non-refugee groups, and the data provided support for the null hypothesis that the distribution of first fixations was not modulated by *group* (BF < 0.17;

Table S5). Overall, the results suggests that the location of the first fixation mostly depends on the interaction between the *AOI* and *emotion,* but that *group* (refugee v non-refugee) does not have an effect.

Post hoc analyses revealed that the children most often tended to initially orient to the eyes of negative emotions (most notably for anger), and to the mouth of positive (happy) expressions (Figure 5, Table S6).

Fixation duration

We found that refugee and non-refugee children had similar average durations of fixations to emotional expressions, with the data providing evidence (BF > 100) for an interaction between *emotion* and *AOI*, indicating that children's average fixation duration depended on the emotional expression. This interaction effect was similar across the two groups, as the data provided evidence for the null hypothesis that fixation duration was not modulated by *group*, either as main effect or in interaction (all BF < 0.07; Table S7). Our results suggest that the average fixation duration depends the most on the *AOI* and *emotion*, but not on *group* (Table S7).

Post hoc analyses showed that refugee and non-refugee children tend to fix their gaze on the mouth of happy expressions for a longer time compared to other emotions, whilst the average gaze duration on the eye region was similar across different emotions (Figure 5, Table S8).

To investigate associations between emotion recognition, trauma, and mental health we calculated non-parametric correlations between emotion recognition and eye-tracking parameters and questionnaire scores (reported in Figures S9 and S10), however after correcting for multiple comparisons, none of the correlations remained significant (Bonferroni correction, al $p > .05$).
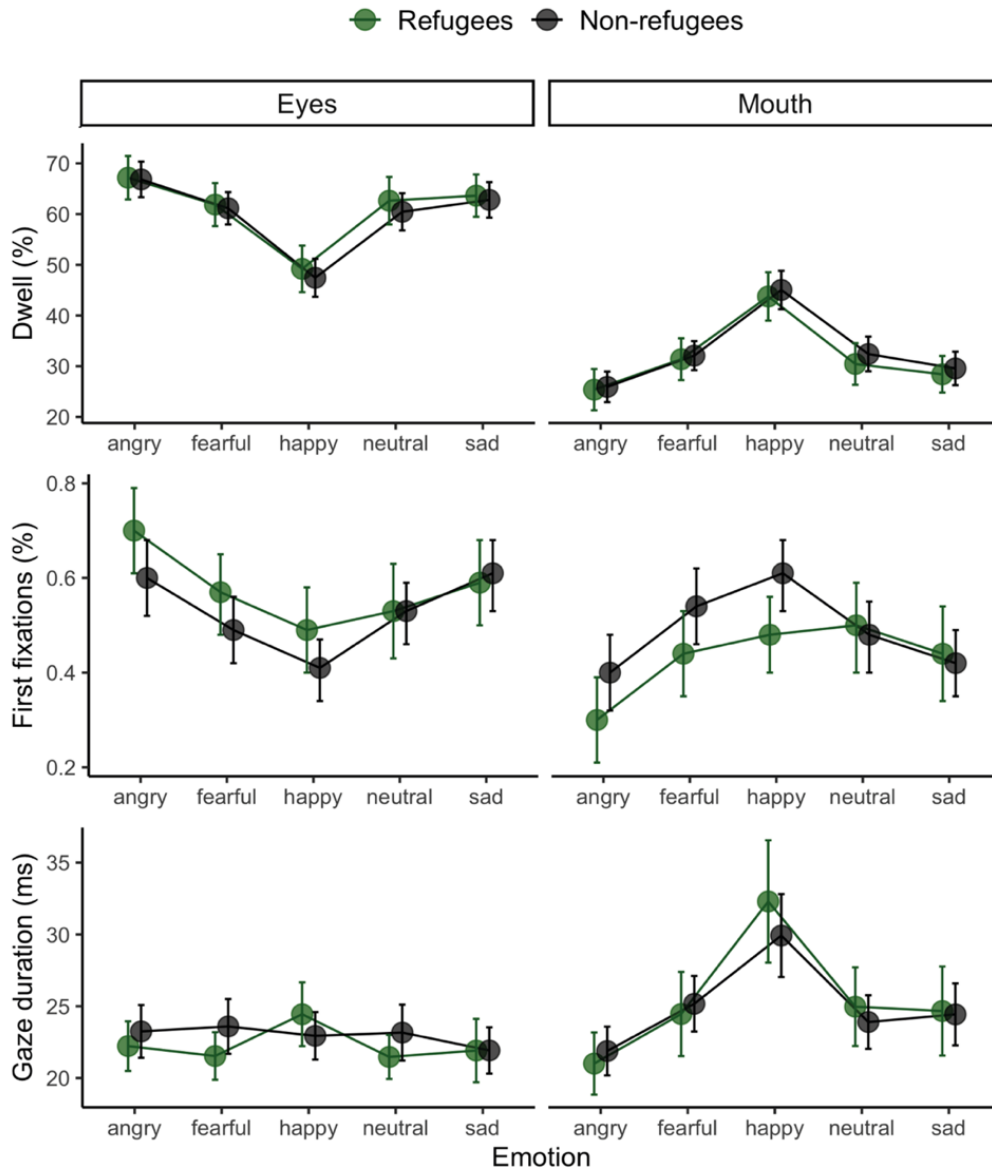
Figure 5. Dwell, proportion of first fixations, and average gaze duration on eyes and mouth for each emotion. Error bars represent 95% confidence intervals

GENERAL DISCUSSION

We examined whether Syrian refugee children with experiences of war-related trauma and displacement have atypical emotion recognition compared to non-refugee Jordanian children, in three different experiments using validated tasks. Despite significant differences in trauma exposure and experiences of forced displacement between our two groups of children, we find no evidence of altered emotion recognition in refugee children compared to Jordanian, non-refugee, children. Surprisingly, we found no group differences in mental health outcomes.

Our experiments suggest that exposure to war-related trauma and displacement during early childhood and infancy, when reported by the caregiver but not always recollected by the child, appear to have little effect on emotion recognition.

Emotion recognition

We first measured children's biases in facial emotion recognition using a standard morphing task (e.g., Pollak & Kistler, 2002). Contrary to our expectations, both refugee and non-refugee children displayed similar biases. They were biased towards perceiving neutral faces as sad on the HS dimensions and displayed no bias towards either fearful or angry expressions on the FA dimension, suggesting that experiences of trauma and refugee status did not affect their emotion recognition on this task. In our second experiment, we measured perceptual encoding of emotional expressions using a maximum likelihood difference scaling paradigm (MLDS). Again, we found that refugee and non-refugee children did not differ in emotion discrimination. Both groups showed a tendency to perceive ambiguous expressions as sad rather than happy (on HS) and showed a small bias for perceiving neutral expressions as more fearful rather than angry (on FA), with refugees making errors more frequently on catch trials in the FA continuum. However, this could be the result of differences in testing conditions (i.e., more refugee children were tested in private homes with more disruptive testing conditions), considering the group similarities in the overall pattern of perceptual encoding. Importantly, the results of the MLDS task suggest that the use of emotion labels and language are unlikely to have influenced the emotion recognition bias outcomes in our first experiment.

Having found that refugee and non-refugee children had similar emotion biases measured using facial morphs, we turned to investigate their emotion recognition and scan paths when viewing single emotional expressions. At this time, a more culturally relevant stimuli set of Iranian actors (Heydari et al., 2022) became available for use, which allowed us

to eliminate any potential *other-race* effects. In line with our findings in the first two experiments, we found that refugee and non-refugee children had similar emotional expression recognition accuracy. We also found that both groups had similar scan paths when viewing all emotional expressions, broadly similar to Western (adult and child) participants, highlighting the relevance of the eye region for all emotions, and the mouth for happy expressions (e.g., Rollins et al., 2021; Schurgin et al., 2014).

Overall, we found that refugee and non-refugee children look at, and categorise, facial expressions in a similar manner, regardless of their levels of trauma exposure. These results differ from previous reports that children with a history of early adversity tend to overidentify angry facial expressions (Pollak et al., 2000; Pollak & Kistler, 2002; Pollak & Sinha, 2002), although previous research focused mainly on childhood maltreatment, whereas the effects of war trauma and displacement on emotion processing are largely unknown. It is likely that traumatic events related to war might have a different impact on children's perception of emotions than other forms of adversity. Indeed, studies show variability in emotion processing atypicalities between children exposed to physical abuse and physical neglect (Pfaltz et al., 2019), and the dimensional model of adversity and psychopathology emphasises differences in neurodevelopmental mechanisms affected by *threat* versus *deprivation* (McLaughlin et al., 2014). In line with this, a recent study on emotion recognition accuracy in refugee youth showed poorer recognition accuracy only for happy and sad expressions (Gredebäck et al., 2021) whereas previous research on maltreated children reports atypicalities in the perception of anger (e.g., Pollak & Kistler, 2002).

There are, however, some important caveats to our results. Firstly, the simplicity of the cumulative model of trauma used in our studies (i.e., checklist) does not account for more

detailed aspects of traumatic experiences, such as how severe they were to the individual, how often and how long ago they occurred, nor how long they lasted. Furthermore, the second-hand nature of trauma reporting used in our studies allows for underreporting (caregivers might not always be aware of all their children's experiences) and overreporting (caregivers who were traumatised themselves might report their children having experienced more trauma); caregiver reports of child trauma exposure often differ substantially from child reports (Skar et al., 2021). A more in-depth exploration of the severity, chronicity, and timing of the reported trauma, as well as insight into the children's own perception of the events, could shed more light on the developmental mechanisms involved in emotion processing and their response to adversity. However, this is particularly challenging in populations of young vulnerable children.

Taken together, our results suggest that caregiver-reported war-related trauma experienced in early childhood might have different effects on emotion perception than childhood abuse or neglect.

Mental health, emotion processing, and psychosocial functioning

Consistent with previous reports (e.g., Ozer et al., 2016; Veronese et al., 2021), we found that refugee children were exposed to more traumatic events than non-refugee children. Surprisingly, refugee and non-refugee children did not differ on any of the other mental health outcomes and their mental health was not predicted by trauma exposure. These findings were largely unexpected, as previous research suggests high prevalence of symptoms of PTSD, depression, and anxiety amongst refugee children (Henley & Robinson, 2011; Panter-Brick et al., 2018), although rates do vary (Frounfelker et al., 2020). Several factors might help to explain why refugee children displayed relatively good mental health and wellbeing, which include the amount of time passed since the adverse experiences, conditions of resettlement (i.e., the majority of participating children live in urban areas of Jordan), living conditions, and

socio-economic status (i.e., the Jordanian non-refugee children live in similar neighbourhoods and do not differ in the levels of poverty). Considering the lack of group differences in our studies and the reports that 85% of refugee families residing outside of camps in Jordan live below the poverty line (UNICEF, 2018), a more precise measure of relative wealth might be necessary to record differences between the groups. Children in our studies also represented a younger cohort of refugees than reported above (e.g., Panter-Brick et al., 2018), and many of them might not have experienced any trauma directly, while those who did might have been too young to have a conscious memory of the event. Furthermore, while we were able to measure children's own perceptions of their mental health, we were not able to assess their own perceptions of adversity, and the way in which they construed the experiences of the potentially traumatic events they were exposed to. Emerging findings suggest that these subjective perceptions of adversity are better predictors of (later) mental health outcomes than objective reports of trauma (Danese & Lewis, 2022; Danese & Widom, 2020). As we expected that poorer mental health would be associated with both trauma and emotion perception biases, our results consistently suggest that conscious awareness and/or memory of the traumatic experience might be necessary for it to affect socio-emotional development in later childhood. Moreover, whilst our studies were primarily concerned with the effects of war-related trauma, a plethora of other factors might also play a role in refugee children's response to adversity. Both risk and protective factors span a range of contexts, from individual, family, community, and societal influences affecting developmental outcomes (Arakelyan & Ager, 2021). The impact of child characteristics, such as their attachment styles and temperament, as well as family dynamics, and community support are known to influence emotional and behavioural outcomes in refugee children (Bryant et al., 2018; Eruyar et al., 2018; Reed et al., 2012). Specifically, refugee caregivers' characteristics, such as trauma exposure, stress, and poorer mental health may lead to higher symptomatology, adjustment difficulties, and socioemotional

problems amongst children (Betancourt et al., 2015; East et al., 2018; Meyer et al., 2017; Miller & Rasmussen, 2017). Refugee parents with poorer mental health and lower levels of social support may use harsher and less warm parenting strategies, which can in turn lead to poorer emotional outcomes in their children (e.g., Bryant et al., 2018; Eltanamly et al., 2021). Indeed, refugee children's difficulties in accurately recognising sad and happy expressions has not only been linked to their mothers' PTSD symptomatology (Gredebäck et al., 2021), but also to mothers' use of harsher parenting strategies, associated with higher vulnerability, discrimination experiences, and less social support (Peltonen et al., 2022). Taken together, these findings emphasise the importance of parental and societal factors on refugee children's emotion processing. Emerging research also highlights the importance of positive social relationships and the associated perceptions of safety as a prominent factor in healthy emotional development and psychosocial functioning, and proposes the *lack of safety* as an arising model of childhood adversity (Smith & Pollak, 2021). Further research in refugee context should investigate the effects of war trauma on emotion perception and mental health across a wider range of ages and types of environments, and consider participants' individual interpretations of adversity and safety, as well as family dynamics, caregiver trauma exposure and wellbeing, and coping strategies.

We also found that emotion recognition was not associated with trauma or mental health outcomes. It is possible that the lack of associations is due to the overall better mental health outcomes in our cohorts. Mental health questionnaire scores suggest that most participating refugee children in our studies are unlikely to fall into a clinical disorder group, and therefore might have escaped maladaptive cognitive processes previously linked to psychopathologies. Furthermore, inconsistencies in findings among children suggest that cognitive patterns of affective processing might differ from those (more reliably) found in adults (e.g., Schepman et

al., 2012; Simcock et al., 2020), which prevents us from making definitive conclusions about the lack of associations between mental health outcomes and emotion recognition. However, our findings are consistent in showing that emotion recognition is not related to the experiences of trauma, or symptoms of PTSD, anxiety, and depression and other mental health measures across different cohorts of children using different types of cognitive tasks (forced choice, non-verbal, eye-tracking).

Limitations

Our findings should be considered in light of several limitations. Firstly, our studies are limited to investigating the perception of emotions displayed in facial expressions, which might not account for real-world viewing of emotional cues that occur across multiple modalities. In addition, facial expressions might not be the most relevant emotion-laden stimulus to use to investigate the impact of war and displacement related trauma. Whilst most studies on childhood maltreatment use faces as stimuli – since this type of adversity reflects interpersonal relationship – perhaps a more fitting stimulus for refugees would be emotionally-loaded images more directly relatable to their experiences, but suitable for children. For instance, McCoy et al. (2016) showed a link between a negative attention bias and neighbourhood crime using affective images, such as photographs of weapons, although these types of stimuli are not appropriate for use in young refugee children. Furthermore, we rarely encounter displays of facial expressions in isolation of other cues. Advances in eye tracking methodology now allow for measuring eye movements in 3D space and in an environment not confined to computer screen stimuli (e.g., Rogers et al., 2018), and could be used to observe attention distribution during social interactions. It is possible that refugee children would perceive and recognise emotions differently when viewing a familiar individual's facial expressions compared to unknown actors. Emerging research also suggests high level of individual differences in

internal representations of emotional expressions, highlighting the need for more nuanced approaches of measuring emotion processing (Binetti et al., 2022). Incorporating more socially relevant tasks might help us understand emotion processing in refugee children in different contexts and circumstances. Additionally, although the eye-tracking study (Study 3) used emotional expressions from the database of Middle Eastern actors (Heydari et al., 2022), it would be informative to measure scan paths on white European actors' faces for comparison, as it is possible that participating children view own-race, culturally familiar faces in a different manner. For example, stimuli novelty, race, and age have been reported to influence scan paths in both children and adults (e.g., Proietti et al., 2015; Wheeler et al., 2011), although as we were investigating group differences, we expect that both Syrian and Jordanian children should be equally affected by any potential other-race effect arising from our stimuli.

It is also worth noting that the *adversity* measure used in our studies is limited to only war and displacement related events, which are conceptually very different from the models of early adversity studied so far. Refugee children continue to experience a multitude of stressors after resettlement in the host country (Frounfelker et al., 2020), and it is possible that these more proximal types of hardships impact their perception of emotions, even over and above the trauma they suffered. Indeed, recent studies suggest that poverty – a deprivation-linked adversity – was a better predictor of executive function than trauma in a sample of Syrian refugee youth living in Jordan (Chen et al., 2019). Additionally, all refugee families in the current studies live in urban neighbourhoods of Amman. Given the characteristics of our cohort of children, our findings might not be applicable to a wider population of refugee children with a history of high and complex trauma exposure and/or those who are living in refugee settlements. Children living in urban neighbourhoods struggle with a unique set of difficulties, including housing and food insecurity, parental employment problems, and lack of social and

economic support, which they might not experience in refugee settlements (e.g., Jacobsen, 2006), and which could potentially influence their mental health and psychosocial wellbeing. Nonetheless, since less than 20% of refugees in Jordan live in refugee camps (UNHCR, 2021b), research on young refugee children resettled in urban areas is essential to further our understanding of the effects of early trauma on affective development and wellbeing in refugee populations. Discrimination, racism, and economic hardship, as well as the need to navigate novel environments (such as new school systems and new language) could play a vital role in further emotional development and psychosocial functioning of refugee children, and those environmental factors should be taken into account not only in future studies but also in intervention development.

Overall, our findings suggest that although refugee children had more experiences of trauma than non-refugee children, their facial emotion recognition seems to be unaffected by these experiences. This study is one of the first to comprehensively investigate refugee children's affective processing with both well-established methodology and a new, semantic- and label-free paradigm, and suggests that not all forms of adversity affect facial emotion recognition. While our results indicate that emotion recognition does not differ between refugee and non-refugee children, other aspects of emotion processing should be further investigated, such as hypervigilance to threat and emotion regulation strategies, to gain a better understanding of the effect of war on children's emotional development.

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