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How do looking patterns, anti-fat bias, and causal weight attributions relate to adults' judgements of child weight?

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ABSTRACT

Prevailing weight-normative approaches to health pressure adults to visually categorise children's weight, despite little understanding of how such judgements are made. There is no evidence this strategy improves child health, and it may harm children with higher weights. To understand decision-making processes and identify potential mechanisms of harm we examined perceptual and attitudinal factors involved in adults' child weight category judgements. Eye movements of 42 adults were tracked while categorizing the weight of 40 computer-generated images of children (aged 4–5 & 10–11 years) varying in size. Questionnaires assessed child-focused weight bias and causal attributions for child weight. Participants' eye movement patterns resembled those previously reported for adult bodies. Categorisation data showed a perceptual bias towards the 'mid-range' category. For higher weight stimuli, participants whose category judgements most closely matched the stimulus's objective weight had higher child-focused anti-fat bias and weaker genetic attributions for child weight – i.e,. adults who 'label' higher weight in children in line with BMI categories report more stigmatising beliefs about such children, suggesting a possible mechanism of harm. Overall, adults' judgements reflect both unalterable perceptual biases and potentially harmful attitudinal factors, calling into question the feasibility and appropriateness of public health efforts to promote visual child weight categorisation.

1. Introduction

The process by which adults visually perceive children's body size and weight is poorly understood. Research into the mechanisms of such perceptions is important for several reasons. First, adults routinely visually appraise the appearance of others, including children (e.g., Boothroyd et al., 2012; Cornelissen et al., 2016a, 2016b; Langlois et al., 2000). Such judgements appear to affect adult attitudes and behaviour towards children (e.g., Peterson et al., 2012; Rogers & Ritter, 2002; Schein & Langlois, 2015). For example, teachers report lower academic expectations of children who are perceived to have a higher weight, treat them differently in their classes, and award them lower grades (Finn et al., 2019) So it is important to understand their determinants. As such, the visual perception of child weight represents a phenomenon of general psychological interest. Second, and arguably more importantly, concerns have been raised about the prevailing weight-normative approach to health (e.g., Hunger et al., 2020; Tylka et al., 2014), which pushes parents and healthcare professionals to apply category-based weight labels and subsequently intervene to reduce higher child weight (e.g., Falconer et al., 2014; Vine et al., 2013). Concerns centre on the lack of evidence to suggest that labelling results in improved child health outcomes and observational evidence of potential harms (Hunger & Tomiyama, 2014; Robinson & Sutin, 2016). Despite these concerns, large-scale weight surveillance campaigns based on this approach exist in numerous countries including Australia, Sweden, the Netherlands, the UK, and the USA (Davidson et al., 2018).

It is therefore important to critically examine and challenge key assumptions that underpin and have been used to justify the weight normative approach. It is assumed that adults are generally *capable* of categorising child weight in line with perceptually arbitrary thresholds, and that parents show *uniquely 'poor'* labelling of higher weight in children for non-perceptual reasons (i.e., it is assumed that parents assign weight descriptors to their children with a lower accuracy level than would be expected of non-parents; Mareno, 2014). The current study gathered data to investigate both assumptions and, as such, our focus is less about *whether* visual child weight categorisation is inappropriate, and more about

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demonstrating *why* it is likely to be inappropriate mechanistically. Third, and relatedly, children perceived as having a higher weight experience multiple forms of stigmatisation and discrimination from family, peers, and educators and are at greater risk of adverse health outcomes (Friedemann et al., 2012; Pont et al., 2017; Small & Aplasca, 2016). The current study therefore also examined whether participants' decisions about children's weight categories were related to their level of bias against children with higher weights and their beliefs about the causes of higher weight in children.

Overall, while weight-related judgements are both common and societally encouraged, adult perceptions of child weight – particularly higher weight – have a clear potential for detrimental effects on children's wellbeing. The current study therefore measured and examined relationships amongst, in a general population sample of adults, looking patterns (a perceptual factor), causal weight attributions and child-focused anti-fat bias (attitudinal factors), and weight-categorisation patterns for computer-generated stimuli showing children with different body sizes.

1.1. Previous research into adult perceptions of children's body size and weight

Previous research into adult perceptions of child weight has centred on parental category judgements for children with a higher weight, with implied (and sometimes explicitly articulated) condemnation and by-proxy stigmatisation of parents who consider their higher weight child(ren) to have a subjectively or objectively 'acceptable' weight (e.g., Manios et al., 2015; Mareno, 2014; Ramos Salas et al., 2021). This mismatch between weight assessments according to (a) parental judgements and (b) measurements plotted on child growth centiles, hereafter referred to as centile-based categories (Lundahl et al., 2014), is characterised in the literature as inaccuracy and narratively positioned as something specific to parents that should be 'fixed' (e.g., Tompkins et al., 2015). This framing remains relatively ubiquitous, and it is a foundational principle of many child weight surveillance and feedback programmes worldwide (Falconer et al., 2014; Vine et al., 2013).

The widespread use of this approach to weight surveillance and feedback is particularly concerning because of its potential harms, and the fact that even its basic underlying assumptions have not been empirically tested. Specifically, it clearly assumes that adults are somehow capable of visually categorising child weight status in line with arbitrary centile thresholds, yet there is no evidence to support this assumption and the literature on perceptual biases in object and figure categorisation would suggest the opposite. For adult stimuli, observers systematically underestimate the centile-based weight category of higher-weight figures (Blanchet et al., 2019; Cornelissen et al., 2016a, 2016b; Parry et al., 2008; Rietmeijer-Mentink et al., 2013), and in fact similar patterns of categorisation are observed for non-figural stimuli (Poulton & Poulton, 1989). There is therefore a need to empirically test this core assumption of current public health campaigns, beginning by examining the unexplored role of perceptual factors.

1.2. The unexplored role of perceptual factors in child weight category judgements

An unacknowledged limitation of existing studies is that they have predominantly captured inter-individual variation in weight categorisation for participants' own child(ren), leading to the assumption that parents who miscategorise do so because it is their own child. Reflecting a broader societal attitude that blames parents for higher weight in children (Wolfson et al., 2015), existing research attributes how parents categorise their child's weight status to low health literacy, low educational level, parenting style, parental resistance and other negative emotions, the parents' own weight, and the gender and age of parent(s) and children (Alshahrani et al., 2021; Garrett-Wright, 2011; Mejia de Grubb et al., 2018; Warkentin et al., 2018). Parents of children with a higher body weight who underestimate their child's centile-based category are frequently portrayed in the popular press as being ignorant and unwilling to face reality (e.g., Elsom, 2019). A key finding that challenges this narrative – and hints instead at the potential role of perceptual factors - is that parents of children with *lower*-than-average weights also typically categorise them as having an average weight (Blanchet et al., 2019). This finding is evident in most of the literature but receives far less popular or research attention, possibly due to widespread anti-fat bias amongst medical and research communities (Lawrence et al., 2021; Tomiyama et al., 2015).

The existing literature provides a working understanding of the basic components of body perception for *adult* stimuli, both inputs and outputs, including looking patterns and the role of powerful perceptual biases that shape categorisation decisions, but we do not have the same for children. Partially because of this, the stigmatising assumption that parents of higher-weight children are uniquely 'ineffective' at child body size categorisation for attitudinal or knowledge-based reasons, and so both *should* and *can* become 'better', has been allowed to stand. Yet there are established perceptual explanations for patterns of weight and size perception for adult figures (Cornelissen et al., 2016a, 2016b) that have not been previously examined for child stimuli. Observers systematically underestimate the size of higher weight figures (and, indeed, larger non-body stimuli) due to two unconscious and unmodifiable visual biases. The first is contraction bias, which arises when one uses a standard reference for a particular object class (such as bodies) against which to estimate the size of other examples of that object (Cornelissen et al., 2016a, 2016b; Poulton and Poulton, 1989). The reference is based on the average of all the bodies an observer has previously seen. When a given body is of a similar size to the reference categorisation is relatively accurate but this decreases as the size difference increases. When this happens, the observer estimates that the body is more similar in size to the reference than it is. As a result, a body smaller in size than the reference will be over-estimated - as seen with parents of children with underweight (Blanchet et al., 2019) - and a larger body will be under-estimated. The second bias is Weber's law, which states that the just noticeable difference (JND) between two objects will be a constant proportion of their magnitude, leading to a constant Weber fraction over the stimulus range (Cornelissen et al., 2016a, 2016b; Gescheider, 2013). Consequently, the absolute difference in size needed to detect a change in size will be higher for larger bodies.

Overall, universal perceptual factors may be able to help explain the patterns of parental categorisation decisions documented in the existing literature, for which parents have been inappropriately held accountable. If this hypothesis is supported, one would expect to see patterns of this type on an *intra-individual* basis for adults in the general population categorising a range of anonymous child stimuli (i.e., this phenomenon would be expected to be observed outside of the parental inter-individual variation currently documented in relation to their own specific child(ren)). In tentative support of this, a small amount of evidence shows that the overall categorisation patterns shown by parents also appear amongst healthcare professionals working with paediatric populations, manifestly calling into question explanations based on parental bias or poor health literacy (e.g., King et al., 2015). As such, the current study set out to examine whether adults in general make similar decisions about children (in general) to test this hypothesis. If this hypothesis is supported, it directly contradicts the assumption that adults' child weight categorisation is completely amenable to intervention: perceptual factors such as contraction bias and Weber's law cannot be altered.

1.3. Looking patterns and child weight judgements

To decide whether one can reasonably apply existing knowledge of the aforementioned perceptual biases to child stimuli, it is also important to ascertain – as part of this study - whether adults visually approach child stimuli in a way that mirrors the behavioural processing of adult stimuli. As such, knowledge of the looking pattern of the observer for child stimuli is an important to build a clearer picture of weight categorisation. Although eye-movement patterns are fundamental to vision, and thus are often classified as a lower-level perceptual process, there is also a strong cognitive input into how the visual information in a scene or stimulus is sampled (König et al., 2016; Liversedge & Findlay, 2000). Thus, conscious and unconscious cognitive biases are likely to influence where individuals look when assessing body weight.

If adult looking patterns for child stimuli resemble those for adult stimuli, one would expect to see several key features. First, observers of adult bodies adopt a characteristic up-and-down looking pattern during decision-making processes. They fixate more upon the abdominal region of higher-weight adult figural stimuli than stimuli showing other weights (Leehr et al., 2018). Second, observers use the thickness of the torso, the presence or absence of bony precipices, and tissue accumulation as cues in weight-related judgements of adult stimuli (Cornelissen et al., 2016a, 2016b; Cornelissen et al., 2018; George et al., 2011). Those whose weight-category decisions are congruent with centile-based categories make greater use of the edges of the torso (Irvine et al., 2019). It is unclear whether similar strategies are employed when estimating a child's weight category, and it is also unclear whether looking patterns vary with the sex, age, and weight category of the child. In the current study we therefore sought to establish whether these basic facets of figural stimulus processing are found when looking at child stimuli, and to establish to what extent visual behaviour (measured via eye-tracking) varied between different types of child stimulus. This not only provides behavioural information about the judgements that adults are widely pressured to undertake, but also indicates whether we can logically extrapolate our existing understanding of perceptual limitations in size judgements for adults and non-figural objects to weight judgements of children.

1.4. Potential negative consequences of 'centile congruent' judgements about children with a higher weight

As discussed previously, the focus on parental underestimation of higher weight, alongside the neglect of perceptual considerations, has led to a proliferation of weight-normative interventions which aim to increase the congruence between adults' judgements and centile-based weight categories (e.g., Pakpour et al., 2011; Perrin et al., 2010; Rune et al., 2015). The underpinning assumption of such interventions is that increased congruence will prompt actions to reduce higher child weight and subsequently improve health outcomes (Gerards et al., 2012), but evidence does not support this premise. Indeed, an observational longitudinal study found that children who reported being informed by a close family member, peer, or teacher that they were "too fat" gained more weight over time than those who did not report this, independent of baseline BMI (Hunger & Tomiyama, 2014). A similar study found that children gained more weight over time when their parents' judgements of their weight category matched their centile-based category (Robinson & Sutin, 2016). In both studies, the detrimental effects of weight stigma on wellbeing provide a plausible explanation for the findings (Pont et al., 2017), although a third study noted no relationship between judgement congruence and weight trajectory (Gerards et al., 2014). Notably, these studies cannot demonstrate a direct link between adults' weight bias and their child weight category judgements because bias itself was not measured, but they clearly suggest the importance of examining potential mechanisms further.

A recent meta-analysis also demonstrated that critical, weight-loss-focused conversations between parents and children are associated with poorer physical self-perceptions, greater dietary restraint, and eating disorder symptoms in children (effect sizes: 0.20–0.47; Gillison et al., 2016) whereas positive, weight inclusive conversations are not. Despite this, several weight surveillance programmes inform parents of their child's centile-based BMI category with the explicit aim of raising parental awareness, but generally without informing parents of the possible negative consequences of discussing this with one's child (e.g., Falconer et al., 2014; Gee, 2015; Konty et al., 2022; Sallis et al., 2019; Thompson and Card-Higginson, 2009). Efforts to focus adult attention upon a child's centile-based weight category do not constitute a risk-free intervention, but they are still widely regarded as such. In summary, parents (and other adults) are actively encouraged to make child weight category judgements and to seek to ensure that these judgements match centile-based categories despite an absence of evidence to support its effectiveness as a health intervention, and some evidence to suggest potential harms. These potential harms may occur via weight bias and related attitudinal factors, but there is a need for a mechanistic understanding of the potential link between bias and patterns of weight categorisation: the current study sought to address this need.

1.5. Attitudinal factors in child weight judgements

Observer attitudes towards child weight constitute a potentially important but underexplored aspect of understanding how and why individuals make specific weight category judgements, and why these judgements may have negative consequences for children. Centile-based categories are typically labelled in stigmatising and weight-normative terms (Pont et al., 2017). Parents of children with a higher weight, and adolescents with a higher weight, report that the terms 'overweight' and 'obese' are not acceptable and can be distressing (Puhl et al., 2011; Puhl et al., 2017). Indeed, individuals in the general population vary in their willingness to use these words, the way they interpret their meaning, and the extent to which they find them acceptable (Dutton et al., 2010; Ellis et al., 2014; Meadows & Daníelsdóttir, 2016). Alongside the perceptual factors discussed previously, one would reasonably expect an individual's willingness to assign these labels (and, relatedly, their underlying level of weight bias) to influence the apparent (in)congruence of their weight judgements with centile-based weight categories (Neumark-Sztainer et al., 2008), but surprisingly this has not been examined empirically. The current study addressed this by examining the association between participants' categorisation patterns and their self-reported weight bias towards children. If participants with higher weight bias assign stigmatising weight labels more frequently, this provides a plausible partial explanation for the previously observed links between adult assignment or acknowledgement of stigmatising higher weight descriptors and negative sequelae for children.

Relatedly, endorsement of specific causal attributions for child weight is also likely to influence willingness to assign stigmatising labels. Joslyn and Haider-Markel (2019) found that members of the public who attributed weight to genetic causes were more sympathetic to individuals with a higher weight and opposed stigmatising and discriminatory practices and policies to a greater degree. In keeping with this, other studies have found that attributions about individual responsibility for weight via so-called controllable factors (dietary intake and physical activity) are associated with more punitive and stigmatising attitudes to higher weight whereas attributions about external and/or biological causes are not (Elran-Barak & Bar-Anan, 2018; Haider-Markel & Joslyn, 2018; Mata & Hertwig, 2018). As such, individuals who emphasise the role of factors such as genetics might be expected to be less willing to assign potentially stigmatising labels to child weight. The current study tested this by examining relationships between participants' categorisation patterns and their causal attributions for child weight. If participants with lower genetic causal weight attributions assigned stigmatising labels to child stimuli more frequently, this would further indicate a potential mechanistic link between categorisation patterns and damaging attitudes to higher weight in children.

1.6. The current study

Thus far, we have set out three objectives for this study, each of which builds on the previous one: first, document basic patterns of looking and categorisation for adults' child weight judgements in a general population sample; second, establish to what extent known perceptual biases shape categorisation patterns; and third, establish how categorisation patterns relate to key attitudinal factors (causal weight attributions and weight bias) that have the potential to do harm to children with higher weights. These interrelated objectives were designed to inform a critical appraisal of core assumptions underlying current weight normative approaches to weight-focused child health promotion which seek to intervene to alter parents' patterns of weight categorisation.

To meet these objectives, we assessed both attitudinal and perceptual factors in adults undertaking the type of child weight judgements parents and healthcare professionals are routinely encouraged to make, using computer generated stimuli. We tracked the eye-movements of these individuals as they viewed images of children and assigned a weight category to the figure. Stimuli were photorealistic computer-generated figures, the development of which has been described elsewhere (Jones et al., 2018), corresponding to specific centiles on the UK90 child growth chart (Wright et al., 2002). We assessed how participants used visual cues in the decision process and evaluated variation in cue-use patterns by stimulus-level factors (age, sex, and size of the figure shown), and by participant-level factors, as this enabled an assessment of the appropriateness of applying existing understandings of adult perceptual biases to these stimuli. We examined the patterns of weight category decisions made for figures of different sizes and evaluated the extent to which this reflected the influence of contraction bias and Weber's law, as these perceptual biases provide important competing explanations for previously reported categorisation patterns attributed to parental attitudinal bias. We also examined whether the congruence of participant judgements with the centile-based category of the figure shown was associated with participants' self-reported levels of child-focused stigma and causality beliefs about higher weight, measured using questionnaires, to obtain insights into the attitudinal correlates of categorisation patterns.

1.7. Hypotheses

1.7.1. Looking patterns

Based on eye tracking studies for adult stimuli, and the tentative expectation that visual attention during processing of child stimuli would mirror adult stimulus processing, it was hypothesised that participants would adopt an up-and-down looking pattern from the face to the mid-thigh of stimuli. Fixation density would be highest for the central abdominal region (George et al., 2011; Irvine et al., 2019) and would increase for both abdominal and chest areas with stimulus size (Leehr et al., 2018). We tentatively expected to detect subtle differences in looking patterns based on the age-group and gender of the child depicted because child weight distribution changes with age and varies with gender. However, there are no relevant existing studies to guide hypotheses as to the nature and distribution of those differences in looking patterns.

1.7.2. Category assignment & attitudinal factors

Drawing on existing evidence about parental weight-related category judgements for children (e.g., Blanchet et al., 2019) and as predicted by contraction bias and Weber's law, we expected that participants would predominantly assign a mid-range descriptor to stimuli across the weight distribution. This would mean that mid-range stimuli would be most frequently categorised in line with their centile-based category compared to stimuli showing a lower or higher simulated BMI. Regarding attitudinal factors, it was expected that participants' categorisation would be less likely to match the centile-based category for larger sized stimuli when they (a) reported lower levels of child-focused weight stigma, and (b) endorsed genetic causes of higher weight more strongly. This is because participants with these beliefs may be less likely to willingly assign stigmatising higher-weight labels, and for this reason it was hypothesised that this relationship would be observed specifically for stimuli depicting a higher weight rather than across the weight range.

2. Materials and methods

2.1. Sample size calculation and participants

Sample size estimation for this study focused on the analysis of eye movement data, rather than behavioural performance, since recruiting participants to attend a laboratory session to have their eye movements recorded is the limiting factor. In the absence of pilot data specific to the paradigm used in this study, we have extracted data from five published studies that used very similar stimuli, measurement methods and analyses (Bateson et al., 2014; Cornelissen et al., 2009; Cornelissen et al., 2016a, 2016b; George et al., 2011; Irvine et al., 2019). Across these studies, comparisons were made between fixation heatmaps when participants were judging body size, attractiveness, and waist-to-hip ratio. We extracted data from 10 such heat map comparisons where the eye movements were recorded only from control group participants, and not, for example, from participants with a diagnosed eating disorder. We then identified the local regions in the heatmaps corresponding to the largest difference between comparison conditions and computed an effect size, d, from this. Effect sizes were corrected for sample sizes, i.e., $n < 50$. The mean effect size, d, for these 10 comparisons was 0.65 ($SD = 0.15$). Finally, we used G*power v 3.1.9.7 (Faul et al., 2009) to estimate a sample size of 39, which is appropriate to detect this effect size at $\alpha = 0.01$, $\beta = 0.9$.

We recruited 42 adult participants. Inclusion criteria were normal or corrected-to-normal vision and fluency in the English language (spoken and written). Participants were recruited from Newcastle University undergraduate and postgraduate student participation pools (online platforms run by the Psychology Department to encourage student involvement in research) and via word of mouth. Undergraduate students received course participation credits for taking part, and no compensation was provided to other participants.

Participant ages ranged from 18 to 49 years ($M = 25.9$; $SD = 9.0$). Eight participants described themselves as men and 34, as women. Forty-one of the participants described themselves as White British and one preferred not to say. Twenty-four were undergraduate students, 9 were postgraduate students and 9 were professionals in full-time employment. Nine participants were parents and 33 were not parents. Participants' mean self-reported body mass index (BMI) was 22.1 kg/m^2 ($SD = 2.6$; range 18.7 – 29.3 kg/m^2).

2.2. Ethics

The study was reviewed and received approval from the Newcastle University Faculty of Medical Sciences research ethics committee (ref no. 11693/2018 and 12718/2018).

2.3. Stimulus preparation

The stimuli feature computer-generated images of children in two age groups, 4–5 years and 10–11 years. This is because children in these age groups are weighed and measured as part of the National Child Measurement Programme in English schools, and their parents informed of the results (NHS Digital, 2021). As such the stimuli match the ages at which the English National Health Service intervenes to provide information about and potentially alter parental perceptions of child weight status. Fig. 1 shows example stimuli.

We previously obtained 3D body shape scans from 598 children aged 4–5 and 10–11 (Jones et al., 2018). Of these, complete data (height, weight, and useable 3D scan data) were obtained from 388 children, all of whom were white (211: 4–5 years old, 53% boys; 177: 10–11 years old, 45% boys). Creation of multiple sets of ethnically diverse stimuli was not possible at this point because children were recruited from North-East England, which has a predominantly white population: at the most recent census, 93.6% of the regional population reported their ethnicity as white British, and 1.7% of the population reported it as white, other (Office for National Statistics, 2020). From these scans, for each age group and gender, a set of 10 CGI models was created representing BMI centiles from low to high using the Daz3D studio programme (Daz3D.com) and the Genesis base body and Genesis Evolution Morphs (Jones et al., 2018). For the current study, we updated the skin, hair and clothing of this image set to reflect improvements in CGI since they were originally created. The ten figures for each of the two age groups and genders represented the full BMI centile range as set out in the UK90 reference (Wright et al., 2002). Each figure was allocated to 1 of 4 levels. Level 1, ≤ 2nd BMI centile; level 2, > 2nd to ≤ 75th BMI centile; level 3, > 75th to ≤ 91st BMI centile; level 4, > 91st BMI centile.

2.4. Eye tracking apparatus

Monocular, right eye-movements were recorded using an Eyelink-1000 Eye Tracker. The Eyelink-1000 system uses a saccade-picker approach to identify saccades by applying an exclusive OR rule to three thresholds: velocity (30°/sec), acceleration (8000°/sec) and distance moved between samples (0.1°). It then treats the rest of the (non-blink) data as fixations, assuming that the “not in a saccade” condition is maintained for at least 50 ms. The stated accuracy of the system is down to a resolution of 0.15°, though 0.25–0.5° is typical. Stimuli were presented on a 19″ flat panel LCD screen (1280 w × 1024 h pixel native resolution, 32-bit colour depth) for 6 s per trial. At the standard viewing distance of ~60 cm, the image frame containing the stimulus subtended ~26° vertically and ~8° horizontally.

2.5. Procedure

After receiving written and verbal information about the study, participants provided written consent. First, participants undertook the eye-tracking weight category judgement task. They then used a laptop computer to self-report demographic and anthropometric information, to report their beliefs about the causes of higher weight in children and to complete a measure of child-focused weight stigma; these questions were delivered and recorded using Qualtrics™.

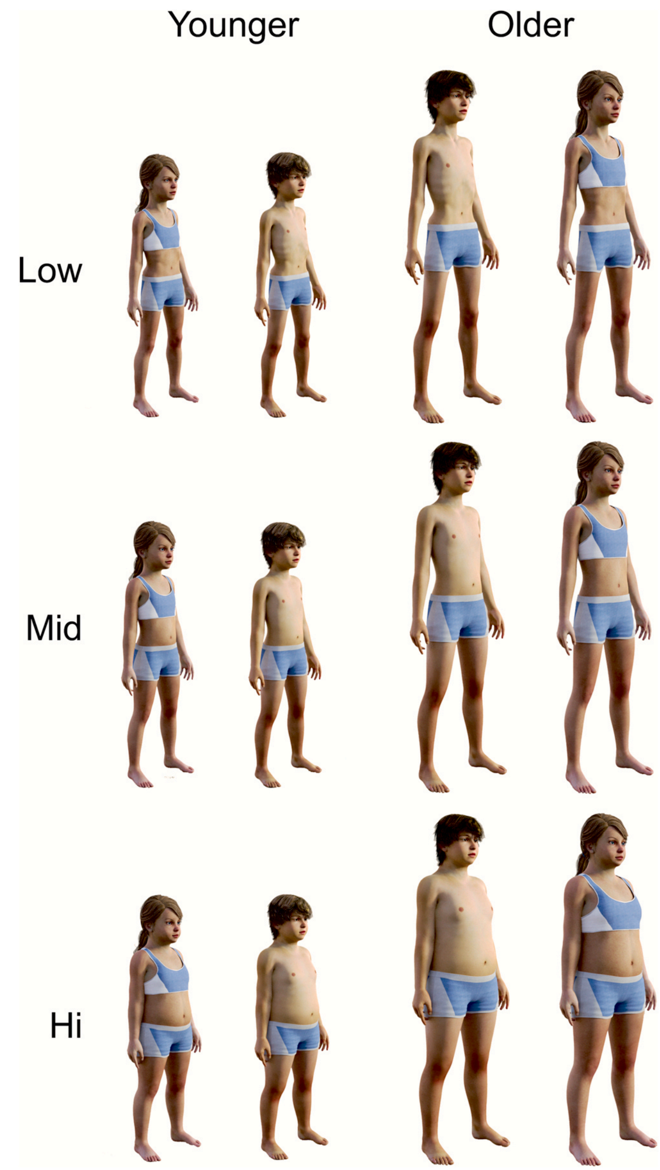

Fig. 1. Example stimuli showing older and younger boys and girls of low, mid, and high simulated BMI.

2.6. Measures

2.6.1. Demographic and anthropometric information

Participants reported their age, ethnicity, gender, and educational/professional category. They indicated whether they had any children under the age of 18, how many, and their age(s) and gender (s). Participants also optionally reported their approximate current weight (in stones and pounds, kilograms, or pounds) and height (in feet and inches, or metres and centimetres).

2.6.2. Weight-related causal attributions

Participants used three separate visual analogue scales to indicate the extent to which they believed three factors (genetics, eating behaviour, and lack of physical activity) contributed to higher weight in children (0 = *not at all* to 100 = *completely*). These items have been used previously when evaluating parental perceptions of the causes of higher weight in children (Parkinson et al., 2015). In a validation sample of 202 participants, these items were significantly associated with scores on the ‘responsibility’ subscale of the Fat Attitudes Assessment Toolkit (FAAT; Cain, Donaghue, & Ditchburn, 2022), which measures internal attributions for higher weight, in the expected directions (Pearson's $r_{(202)}$ for genetics: −0.32; diet:.38; physical activity:.25; all $p < .001$). Over a period of 7 days, test-retest reliability was found to be adequate for each VAS item (Pearson's $r_{(101)}$ for genetics:.76; diet:.64; physical activity:.60; all $p < .001$).

2.6.3. Child-focused weight stigma

There is not an existing measure to assess the extent to which adults stigmatise children of higher weights. We therefore adapted five positively keyed items from the weight control/blame subscale of the Anti-Fat Attitude Test (AFAT; Lewis et al., 1997) for use (available in Online Supplementary Material). References to *people* were changed to *children* throughout, and other minor adaptations made to ensure items made sense in the context of childhood e.g., a reference to buying food was changed to eating food. In line with the original test, items were scored on a 5-point Likert scale where 1 = strongly disagree and 5 = strongly agree. This newly adapted 5 item scale had an internal consistency (Cronbach's alpha) with this study sample of.86, comparable to that of.84 obtained with our validation sample. An exploratory principal component analysis of validation data using varimax rotation produced a single factor onto which all scale items loaded satisfactorily. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy (which indicates the degree of diffusion in the pattern of correlations) was 0.82. Bartlett's test of sphericity was significant (chi-square (df) = 380.72 (10), $p < .0001$). One factor had an Eigen value greater than Kaiser's criterion of 1 (i.e., 3.07) which explained 61.3% of the variance. The scree plot showed an inflexion, i.e., Cattel's criterion which also justified retaining just the one factor. The residuals were all small, and the overall root mean square off-diagonal residual was 0.1., indicating that the factor structure explained most of the correlations. The factor loadings for the five items were, respectively: 0.78, 0.80, 0.83, 0.77, and 0.74. As part of the validation process, we found that scale scores were strongly associated with the original AFAT control/blame subscale ($r_{(202)} = 0.79$, $p < .001$) and with the FAAT subscale for responsibility ($r_{(202)} = 0.67$). Child focused weight stigma scores were also negatively associated with FAAT size acceptance and empathy subscale scores ($r_{(202)} = -0.56$ and −0.55, respectively, both $p < .001$). Overall, this demonstrates the construct validity of the scale. The scale showed adequate test-retest reliability over 7 days ($r_{(101)} = 0.75$). Scores were not found to be significantly associated ($r_{(202)} = 0.03$, $p = .63$) with a measure of socially desirable responding (The Social Desirability Scale-17; Stöber, 2001).

2.6.4. Eye tracking task

Participants sat in a dimly illuminated room with their heads supported by a combined head and chin rest. Movements of the right eye were recorded with an Eyelink 1000 eye-tracker at a sample rate of 1000 Hz. Stimuli were presented on a flat panel LCD monitor at a standard viewing distance of about ~60 cm. At the start of the session, participants' eye movements were calibrated using a nine-point calibration screen. Once the calibration procedure was validated, the experimental body weight perception task began.

Participants viewed a randomized sequence of images of a child's figure. On each trial of the task, one image was presented, and participants were required to classify the body using four descriptors. These descriptors were selected because they are routinely used by healthcare professionals in the UK National Health Service. These descriptors were *underweight, healthy weight, overweight* and *very overweight*. Our use of these terms for this purpose does not in any way imply an endorsement of the weight-normative approach which inappropriately equates weight status with health status. Each of the 40 stimulus images was presented once, in random order.

The presentation of each body was preceded by a fixation spot, picked at random from one of four locations: top left, bottom left, top right, or bottom right of the presentation screen. When the eye-tracker software had detected that the participant had continuously fixated the fixation spot for 1000 ms, it was replaced by one of the body stimuli which appeared centred on the middle of the screen. The requirement to fixate the fixation spot prevented any anticipatory eye movements. The stimulus remained on screen for 6 s, after which a blank screen was displayed. Only at this point did participants verbally report their estimation of the weight descriptor the figure previously shown. Participants then pressed the space bar to start the next trial which again began with the fixation spot.

2.7. Statistical analysis

2.7.1. Eye-movement data processing and analysis

The analysis focused on the areas of the stimulus bodies which showed relative differences in participants' gaze patterns across experimental conditions. This is a particular challenge when comparing fixation patterns for images showing younger children with images showing older children due to differences in height and bodily proportions. Therefore, to do this, we first morphed all the images of the bodies in our stimulus set together to produce an average or reference body image. This morphing procedure generated a set of coordinate transforms which mapped the individual pixels from each of the original images onto the pixels in the reference image (Hancock, 2000). By applying the same set of transforms to the horizontal (x) and vertical (y) coordinates of our eye-movement records, we transformed the eye movements for each observer into the same spatial framework and co-registered the fixation patterns with the reference body image to create gaze heatmaps.

To allow relative comparisons between conditions, these data were normalized separately for the sex (boy versus girl), age (younger versus older) and BMI category (low, i.e., ≤ 2nd centile; mid, i.e., > 2nd to < 91st centile; high, i.e., ≥ 91st centile) of the stimulus image, so that the total volume under the surface of each heat map was the same. Note that for the purposes of the eye-movement analysis, we used a three-level classification of BMI (as compared to the 4 levels used for the behavioural analysis), in order to retain as many eye movement samples as possible per category. This strategy improves statistical power. To examine the spatial distributions of fixations on the reference body, and to compare fixation patterns across experimental conditions, we then constructed a sampling grid of square cells, 20 × 20 pixels each, and applied it across the entire reference image (height 880 pixels, width 600 pixels) (for further details see Cornelissen et al., 2016a, 2016b; 2009). This cell size (20 ×20 pixels) represents a compromise between capturing as many fixation samples per cell as possible to optimize statistical power (which ideally requires large cells) versus retaining good anatomical resolution (which ideally requires small cells).

We modelled differences in normalized fixation density between experimental conditions by applying linear mixed effects models implemented in PROC MIXED in SAS v9.4 (SAS Institute, North Carolina, USA). In each statistical model, we took account of the repeated measures i.e., each participant contributed a number of fixations to the sampling grid (defined by row and column indices in the model) for each of the body images, and we integrated spatial variability into the models by specifying a Gaussian spatial correlation model for the model residuals. The MIXED procedure was then used to assess where on the stimulus images there were significant differences in fixation density between experimental conditions. Areas of significant difference are indicated by the white contours ($p < .01$) in Fig. 4 and are based on the estimated marginal means derived from the model parameters. These predicted population margins are compared using tests for simple effects by partitioning the interaction effects.

2.7.2. Non-eye-movement data analysis

Participant body mass index (BMI) was calculated (weight/height^2) after converting self-reported weights to kilograms and heights to metres. We used PROC GLIMMIX (SAS v9.4) to build a generalised linear mixed model to elucidate factors that predicted whether participants applied the four weight categories in line with centile-based categories or not. We assumed a binary distribution for the outcome and therefore used a logit link function. We also included a random effect for each participant's intercept. The model was optimized by ensuring that (a) any fixed effect added to a model contributed a statistically significant reduction in −2 Log Likelihood, (b) fixed effects were retained in a model only if their Type III test of fixed effects was significant at $p < .05$. The only potential exceptions to this were if one non-significant fixed effect comprised part of a significant two- or three-way interaction term, in which case it was retained. There were no missing data amongst the non-eye-movement data.

3. Results

3.1. Child-focused weight stigma and causal attributions for higher weight in children

On the visual analogue scales, which rated the extent to which participants attributed higher weight in children to genetic causes (genetic attribution), dietary causes (dietary attribution), and low physical activity (PA attribution) from 0 to 100, participants scored $M = 36.1$ ($SD = 16.1$), $M = 75.2$ ($SD = 14.5$), and $M = 77.5$, ($SD = 12.9$), respectively. This indicates that participants, overall, reported a stronger belief in the causal roles of dietary intake and physical activity than genetics. The mean level of child-focused weight stigma was $M = 13.63$ ($SD = 4.36$) out of a possible minimum of 5 and possible maximum of 25; higher scores indicated a higher level of stigma.

3.2. Categorisation patterns: correspondence between weight category judgements and stimulus centile-based weight category

Table 1 is a set of confusion matrices showing patterns of correspondence between the centile-based weight category of the stimulus (S) according to the UK90 growth reference (Wright et al., 2002) and the judgement reported by the participant (R). Values in cells show the percentage of stimuli in each weight category distributed amongst the 4 possible response categories, separately for younger and older girls and boys. Shaded cells indicate congruent responses i.e., the percentage of trials (calculated separately for each row) in which the participant response category matched the centile-based category.

The greatest proportion of participants' judgements corresponded to the centile-based category for level 2 stimuli i.e., figures with mid-range weights (S2; range = 87–95.1%). This proportion was lower for level 1 stimuli (S1; range = 72–89%). Finally, a lower proportion of participant judgements matched the centile-based category for level 3 stimuli (S3; range = 19.5–48.8%) and level 4 stimuli (S4; range = 36.6–48%). This indicated that the categories assigned by participants for figures in the mid-range were more likely to match the centile-based category than for figures either below or above the mid-range.

3.3. Variables associated with participant categorisation patterns

The likelihood of a participant's judgement corresponding to the centile-based category of the figure was examined using generalized linear mixed models. Dichotomous match/mismatch was regressed upon a series of pre-specified predictors to examine variables associated with categorisation patterns. Stimulus characteristics examined were stimulus age group (younger vs older), stimulus gender (boy vs girl) and centile-based weight category. The participant characteristics examined were participant gender, participant parental status (yes/no), and participant self-reported BMI. Attitudinal constructs examined were: (a) participant ratings (0−100) of the extent to which they attributed higher weight in children to genetic causes (genetic attribution), insufficient physical activity (PA attribution) and dietary causes (diet attribution); and (b) child-focused weight stigma score. Each of these constructs was recoded into a two-level factor based on a median split. Table 2 shows the parameter estimates for the final generalized linear mixed model.

In the final model, the fixed effects of the stimulus centile-based category, $F(3,1547) = 97.36$, $p < .0001$, the interaction between stimulus gender and stimulus centile-based category, $F(3,1547) = 5.77$, $p = .0006$, the interaction between genetic attribution and stimulus centile-based category, $F(3,1547) = 3.10$, $p = .03$, and the interaction between stimulus centile-based category and child-focused weight stigma, $F(3,1547) = 8.58$, $p < .0001$, all predicted the likelihood that the participant's weight judgement would correspond to the centile-based weight category of the stimulus. There was no effect of stimulus age group, dietary attribution, physical activity attribution or the parental status, gender, or BMI of participants.

Post-hoc tests showed that, overall, participant judgements were more likely to correspond to the centile-based categories for level 2 stimuli (mid-range weight) than level 1 stimuli ($t = -2.86$, $p = .004$, $OR = 0.48$). Participant judgements were also more likely to match the centile-based categories for level 2 stimuli than for the level 3 stimuli ($t = 14.07$, $p < .0001$, $OR = 40.73$) or level 4 stimuli ($t = 13.34$, $p < .0001$, $OR = 19.09$). The likelihood of matching was lower for level 3 stimuli than level 4 stimuli ($t = -3.55$, $p = .0004$, $OR = 0.47$). These findings are in line with the data shown in the confusion matrix (Table 1).

Participants with low genetic attributions for child weight were more likely to categorise stimuli in line with centile-based weight categories for level 2 ($t = -2.19$, $p = .03$, $OR = 0.37$), level 3 ($t = -2.81$, $p = .005$, $OR = 0.30$) and level 4 ($t = -2.31$, $p = .02$, $OR = 0.46$) stimuli, compared to participants with high genetic attributions. However, there was no difference in categorization related to genetic attribution for level 1 stimuli ($t = 0.54$, $p = .60$, $OR = 1.26$). This indicates that the judgements of participants with high genetic attributions for child weight were less likely to correspond to the centile-based categories for figures depicting BMIs at and above the average range, but not below.

Finally, participants with higher levels of child-focused weight stigma were more likely to categorise stimuli in line with centile-based weight categories for level 1 stimuli ($t = 2.68$, $p = .008$, $OR = 2.84$), and level 3 stimuli ($t = 2.43$, $p = .02$, $OR = 2.31$), compared to participants with lower levels of levels of child-focused weight stigma. There was a non-significant trend in the same direction for level 4 stimuli. By contrast, participants with lower levels of child-focused weight stigma were more likely to categorise stimuli in line with centile-based weight categories for level 2 stimuli ($t = -2.99$, $p = .003$, $OR = 0.27$), compared to participants with higher levels of levels of child-focused weight stigma. This indicates that the judgements of participants with higher levels of child-focused weight stigma were more likely to match the centile-based categories for figures depicting BMIs below and above the average range (albeit with only a trend towards significance for level 4 stimuli), and less likely to do so for figures depicting average-range BMIs.

3.4. Looking patterns and variation by stimulus gender, age, and centile-based weight category

Fig. 2 summarises the normalised fixation density for stimuli showing younger and older boys and girls in low, (≤ 2nd centile),

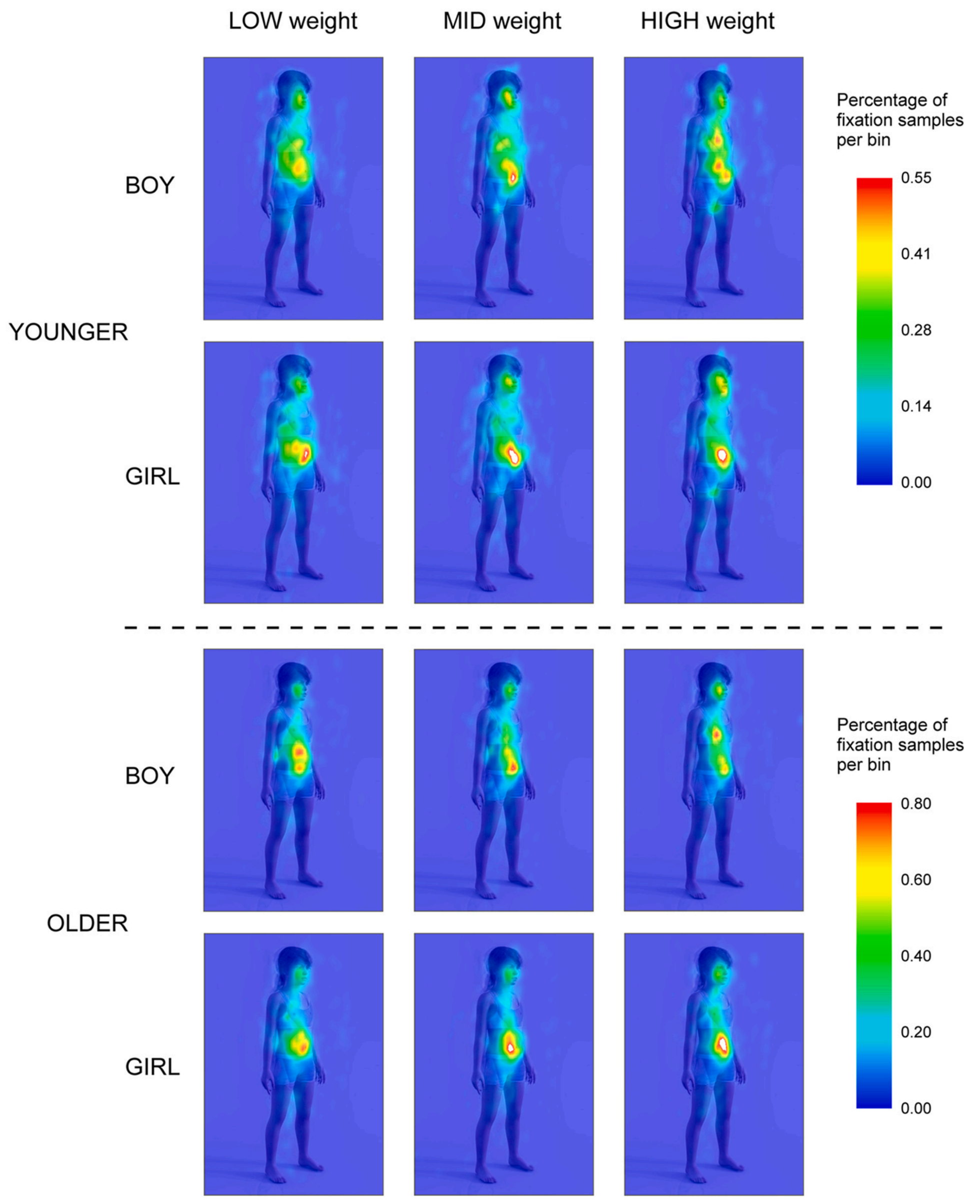

Fig. 2. Percentage of fixation samples on regions of stimuli showing older and younger boys and girls of low, mid, and high simulated BMI.

mid, (> 2nd to < 91st centile), and high (≥ 91st centile) weight categories. From visual inspection of these images, we generated a list of observed differences whose reliability we quantified via subsequent statistical testing.

Across all conditions, participants adopted an overall strategy of up-and-down looking between and including upper-thigh and face. Normalised fixation density was highest (i.e., yellow and red heatmap colours) for the abdominal region for every category of stimulus age, sex, and centile-based weight category. For stimuli showing girls (both younger and older), highest fixation density was largely restricted to the abdominal region, whereas both the abdomen and the chest region were involved for stimuli showing boys (both younger and older). Moreover, the inclusion of high fixation density on the chests of stimuli showing boys was more salient as their simulated BMI increased.

Fig. 3a shows statistically significant differences in normalised fixation density for stimuli depicting boys and girls, collapsed across weight and age categories. Participants fixated significantly more on boys' chests than girls', and more on the central abdominal region of girls compared to boys.

Fig. 3b shows differences in normalised fixation density for stimuli depicting older and younger children, collapsed across sex and weight categories. Participants fixated significantly more on the central abdominal region of stimuli showing older compared to younger children.

Fig. 3c shows differences in normalised fixation density for stimuli from the higher (i.e., ≥ 91st) BMI centiles (collapsed across age and sex categories) which were categorised in line with the centile-based category, compared to those which were not. Participants fixated significantly more on the chest and central abdominal regions for stimuli judged in line with the centile-based category. For stimuli *not* judged in line with the centile-based category, normalised fixation was significantly denser towards the left-hand edge of the abdomen.

Fig. 4 shows the results of the statistical tests undertaken based on the observed differences in fixation density between lower

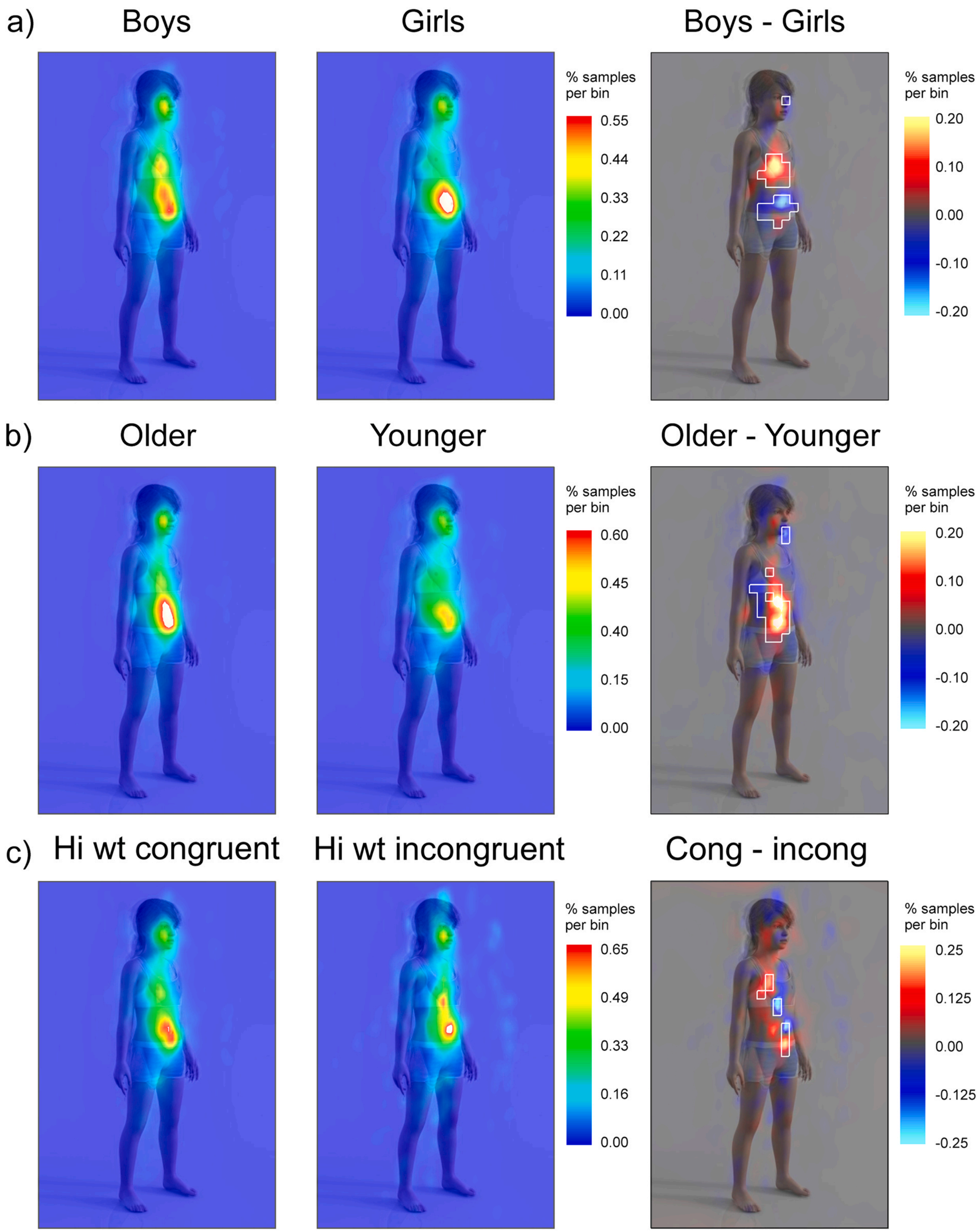

Fig. 3. Differences in fixation density for body areas of stimuli compared on stimulus age, stimulus gender, and whether or not the weight category judgement was centile-category congruent. Fig. 3 shows the results of the statistical tests undertaken based on the observed differences to assess stimulus areas in which there were significant differences in fixation density for: (a) gender, (b) age, and (c) weight judgement centile congruence for higher (i.e., ≥ 91st) BMI centile stimuli. From left to right, the first two columns show fixation density systematically increasing from blue, through green to yellow and red colours in the heatmaps. The third column shows difference heatmaps, where red colours show positive differences (e.g., in a) where boys > girls), and blue colours show negative differences (e.g., in a) where boys < girls). Where these areas of difference reach statistical significance at $p < .01$, the sample bins from which the differences are derived are outlined in white.

weight stimuli and higher weight stimuli, separated for stimulus sex. For higher weight female stimuli in Fig. 4a, the face and left-hand-side of the abdomen had greater normalised fixation density compared to lower weight stimuli. Lower weight female stimuli showed a more distributed normalised fixation density across the breadth of the abdomen, including the right-hand-side of the body, compared to higher weight female stimuli. Fig. 4b shows significantly greater normalised fixation density on the chest area for higher weight male

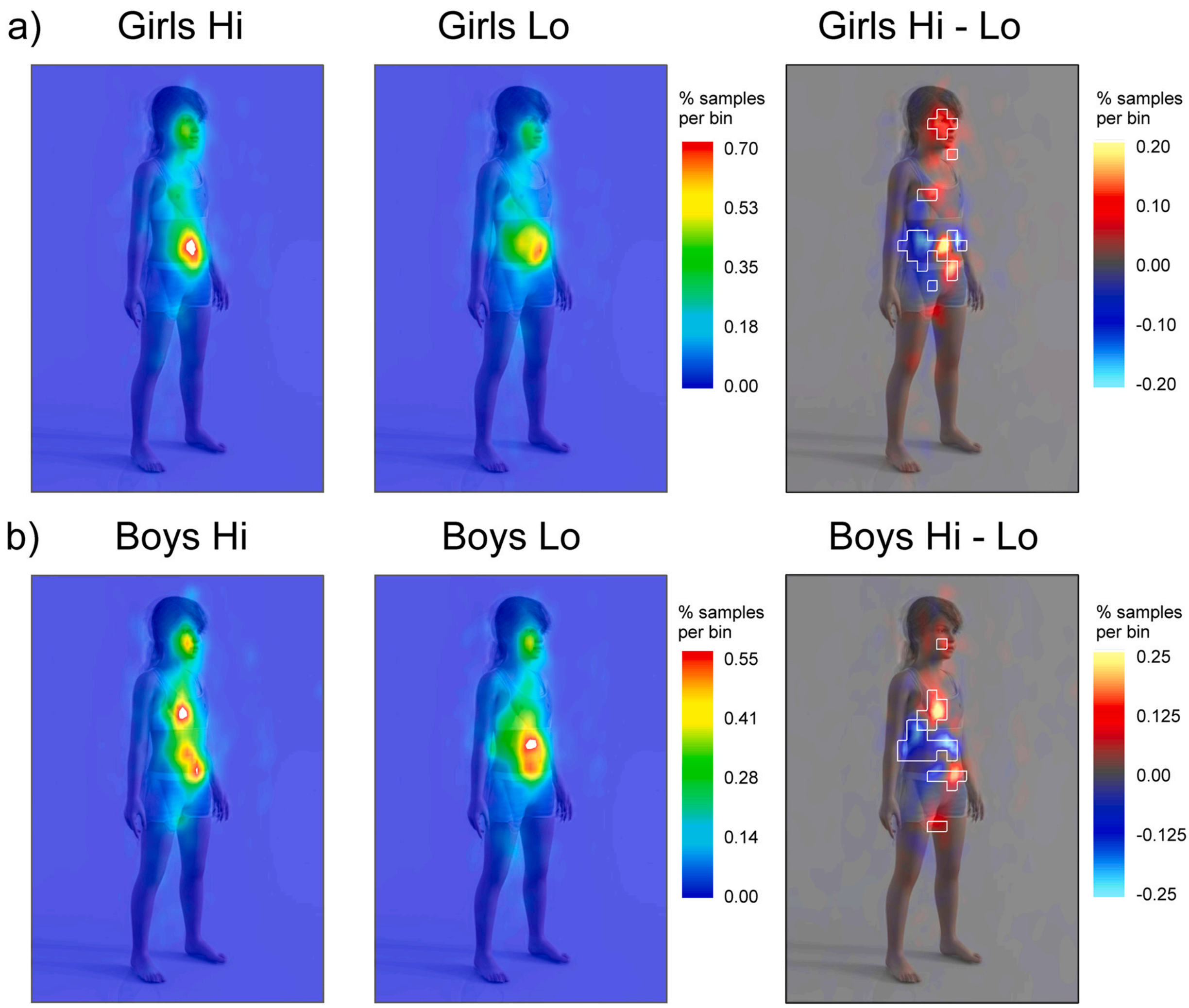

Fig. 4. Areas of stimuli with differences in normalised fixation density by centile-based weight category (lower vs higher simulated BMI) for stimuli showing (a) girls, and (b) boys.

Table 1
Confusion matrices showing the proportion (%) of participant weight judgements that corresponded to the centile-based category for stimuli depicting older (age 10–11 years) and younger (age 4–5 years) girls and boys.

		Girls					Boys			
		R1	**R2**	**R3**	**R4**		**R1**	**R2**	**R3**	**R4**
	S1	72.0	28.0	0.0	0.0	S1	84.1	15.6	0.0	0.0
Younger	S2	4.1	95.1	0.8	0.0	S2	13.0	87.0	0.0	0.0
	S3	0.0	47.6	48.8	3.7	S3	1.2	67.1	31.7	0.0
	S4	0.8	4.1	58.5	36.6	S4	0.0	4.1	57.7	38.2
		R1	R2	R3	R4		R1	R2	R3	R4
	S1	74.4	25.6	0.0	0.0	S1	59.9	40.1	0.0	0.0
Older	S2	12.2	76.3	10.2	0.4	S2	4.9	92.7	2.4	0.0
	S3	0.0	80.5	19.5	0.0	S3	0.0	59.1	40.9	0.0
	S4	0.0	17.5	75.5	6.9	S4	0.3	21.2	71.9	6.6

Note. S = stimulus, R = response. 1 is ≤ 2nd BMI centile; 2 is > 2nd to ≤ 75th BMI centile; 3 is > 75th to ≤ 91st BMI centile; 4 is > 91st BMI centile.

stimuli compared to lower weight stimuli. For lower weight male stimuli, participants fixated more on the general abdominal region than for higher weight stimuli.

4. Discussion

This study aimed to critically evaluate the role of adult perceptual and attitudinal factors in child weight judgement categorisation, with the goal of explicitly testing previously unexamined assumptions about the process. In service of this aim, the study objectives were threefold: first, document basic patterns of looking and categorisation for adults' weight judgements of child stimuli in a general population sample in order to evaluate the extent to which they mirror processes for adult stimuli; second, establish to what extent known perceptual limitations shape categorisation patterns; and third, establish how categorisation patterns relate to key attitudinal factors (causal weight attributions and stigma) that have the potential to do harm to children with higher weights. Together, these objectives enabled the evaluation of key assumptions that have been used to underpin and justify weight normative approaches to child weight and health promotion which seek to intervene to alter parents' patterns of weight categorisation.

This paper documents for the first time that previously observed patterns of differences between parental and centile-based categories of child weight (e.g., Blanchet et al., 2019; Lundahl et al., 2014) are also observed in a general population sample of adults categorising anonymous child stimuli. In this Discussion, we begin by contextualising these findings and summarising the perceptual biases that provide an explanation for this pattern. We demonstrate how the presence of these patterns in a general population sample directly challenges current ingrained assumptions about intervening to alter parental 'poor performance' of child weight categorisation. We then discuss the finding that participants' looking patterns for

Table 2
Regression of participant weight category judgment correspondence with centile-based weight category on predictive variables: output from generalized linear mixed model.

Model Parameter	*t*-value (*df*)	*Z*-value	*p*-value	Parameter estimate (ln odds)	95% CI	-2 Log Likelihood
Empty model						2095.42
Full model						1541.98
Fixed effects:						
Intercept	-1.47 (37)		.200	-0.38	-0.89 – 0.14	
SW	2.95 (1547)		.003	1) 0.97	0.32 – 1.61	
	8.90 (1547)		< .0001	2) 4.37	3.40 – 5.33	
	-1.72 (1547)		.090	3) -0.55	-1.17 – 0.077	
SG	0.79 (1547)		.400	B 0.15	-0.23 – 0.54	
SG × SW	2.00 (1547)		.050	B, 1) 0.73	0.015 – 1.44	
	-2.57 (1547)		.010	B, 2) -1.00	-1.77 – -0.24	
	-1.82 (1547)		.100	B, 3) -0.53	-1.18 – 0.11	
GA	-2.31 (1547)		.020	Hi -0.77	-1.43 – -0.12	
GA × SW	2.34 (1547)		.020	Hi, 1) 1.00	0.16 – 1.84	
	-0.48 (1547)		.600	Hi, 2) -0.22	-1.11 – 0.67	
	-1.03 (1547)		.300	Hi, 3) -0.44	-1.29 – 0.40	
CS	0.97 (1547)		.300	Hi) 0.28	-0.29 – 0.85	
CS × SW	1.97 (1547)		.050	Hi, 1) 0.76	0.0048 – 1.52	
	-3.64 (1547)		.0003	Hi, 2) -1.61	-2.48 – -0.74	
	1.64 (1547)		.100	Hi, 3) 0.55	-0.11 – 1.22	
Random effect:						
Ppt variance, intercept		3.07	.001	0.41		

Note. SW = Stimulus centile-based weight category (1 is ≤ 2nd centile; 2 is > 2nd to ≤ 75th centile; 3 is > 75th to ≤ 91st centile; 4 is > 91st centile); SG = Stimulus gender (G=girl; B=boy); GA = Genetic attribution (high versus low levels); CS = child-focused weight stigma score (high versus low levels). All four explanatory variables have been dummy coded. Their respective reference levels are: stimulus centile-based weight category = 4; stimulus sex = M; genetic attribution = low; child-focused weight stigma score = low.

these child stimuli closely mirror those documented in the previous literature for adult stimuli. We argue that this fundamentally supports the appropriateness of applying existing perceptual theory to understanding child weight categorisation judgements. Finally, we discuss our novel findings that higher child-focused weight stigma and lower genetic weight attributions were broadly associated with a greater proportion of centile-category ‘matched’ weight judgements for larger-sized stimuli. Specifically, we examine how the findings suggest potential mechanisms for the harmful effects of weight categorisation on children, further calling into question the still widely held assumption that intervening to alter adult visual categorisation patterns must be beneficial to child health.

4.1. Perceptual factors in child weight judgements

The observed pattern of child weight categorisation decisions, in which participants categorised most stimuli as belonging to the mid-range, closely replicate those seen in parents and HCPs (Blanchet et al., 2019; King et al., 2015). Specifically, stimuli both above and below the mid-range were less likely to be assigned a category that matched the centile-based category. This is the first time that these characteristic patterns of categorisation have been demonstrated in a general population sample viewing ‘anonymous’ child stimuli (vs a known child), most of whom were not parents. Our findings show that these categorisation patterns are certainly not confined to those with regular interactions with individual children, but instead generalise more widely to adult observers of CGI stimuli. This fundamentally challenges the premise that parents uniquely and culpably demonstrate an “alarming disconnect” between objective and subjective appraisals of their child(ren)’s higher weight (Doolen et al., 2009, p. 161). Notably, it highlights the inaccuracy of the damaging and inappropriate narratives which attribute parental categorisation patterns to ignorance and denial, and which imply that child weight categories are obviously visually apparent to the casual observer (e.g., Elsom, 2019; Hope, 2014; McDermott, 2019).

Participants’ categorisation judgements showed clear behavioural evidence of contraction bias through increased incongruence of participant judgements with centile-based categories as the weight of the images moved below or above the mid-range (see Table 1). Contraction bias occurs because size estimations are made by comparison with an internal reference based on the average of the bodies someone has seen, which in practice roughly corresponds to a weight in the mid-range (Cornelissen et al., 2013). Additionally, judgements of body size for higher weight stimuli are likely to have been affected by Weber’s law, which means that differences between bodies of higher weight are more difficult to perceive (Cornelissen et al., 2016a, 2016b). Importantly, both contraction bias and Weber’s law are involuntary and unconscious and not amenable to intervention. This very strongly implies that consistently centile-congruent categorisation is fundamentally constrained by perceptual biases for most adults i.e., it is mechanistically impossible. As such, aside from their clear risks of harm to children, weight-normative public health campaigns which aim to shape individuals’ current and future categorisation judgements for children with higher weights via written feedback and information are highly likely to be ineffective. We also found that weight categorisation patterns varied according to stimulus gender: congruence between participant and centile-based judgements was lower for stimuli showing girls than boys, in line with some of the existing (mixed) evidence from parents (Blanchet et al., 2019). However, the apparent effect of stimulus sex may be explained by clothing differences in stimuli depicting boys vs girls rather than any intrinsic gender-related difference in task performance, and there was no effect of stimulus age group. In keeping with previous studies, observer BMI and gender were unrelated to judgement congruence (Lundahl et al., 2014).

Overall, these findings support the vital importance of recognising that perceptual biases at least partially drive the tendency towards so-called misclassification widely reported with previous (often parental) samples. Perceptual biases, such as Weber’s law and contraction bias, make size related judgements particularly difficult (Cornelissen et al., 2016a, 2016b). These biases reliably produce the predictable patterns of responding that we observed in adults classifying anonymous child stimuli, clearly dispelling the notion that parents are specifically ‘underperforming’. They also undermine the core assumptions of weight-normative interventions that aim to alter categorisations of child body size in parent or healthcare professional groups. Indeed, the division of body sizes into the weight categories is entirely perceptually arbitrary and there are no reasons that humans should be able to allocate bodies to artificial categories despite strong external pressures to do so.

4.2. Looking patterns in child weight judgements

This study also aimed to establish a foundational understanding of basic looking behaviours in adult judgements of child weight categories, given the complete absence of existing work in this area. If we found that such behaviours did not broadly reflect existing looking patterns for adult stimuli, this would call into question the appropriateness of applying existing theories of perceptual bias (such as contraction bias) to understanding categorisation patterns for child stimuli. Notably, because children's bodies are proportioned differently to adults', and weight distribution alters with age, it was not unreasonable to consider that a different set of looking patterns might arise. However, our eye-tracking findings broadly aligned with what is already known about adult looking patterns. Our participants looked up and down the child figures as predicted, fixating principally on the stomach and to a lesser extent on the chest. This looking pattern fits with eye-movements and predominant fixation patterns when people make decisions about adult weights (Cornelissen et al., 2016a, 2016b; Irvine et al., 2019). As stimulus weight increased, fixation on parts of the stomach and chest area increased, again in line with adult findings (Leehr et al., 2018). We also found that central fixation on the abdominal region predicted a greater correspondence between centile-based and participant categorisations. This is consistent with Irvine et al. (2019) in which higher levels of central foveation within the body outline were associated with similar categorisation patterns. We found that fixation patterns subtly differed for stimuli showing children aged 4–5 years and children aged 10–11 years, likely reflecting the changing pattern of weight distribution and body proportions with child age (e.g., Katzmarzyk et al., 2012). We also noted different looking patterns for stimuli showing boys and girls, which may also reflect differences in weight distribution, but we cannot exclude the possibility that these occurred due to differences in the garments worn by the figures. In the case of both age and gender, fundamental physical differences between children and adults precluded direct comparisons with existing eye tracking research using adult stimuli.

Overall, a comparison of our findings with what is already known about looking patterns for adult stimuli demonstrates considerable similarity with the existing literature. Areas of fixation for weight-related decisions in particular mirror those for adults i.e., observers appear to draw on similar sources of information. This conclusion supports the appropriateness of applying existing perceptual theories to understanding weight category decisions for children, as we have done, despite the obvious physical differences between child and adult stimuli.

4.3. Attitudinal factors in child weight judgements

In line with the existing literature, participants in our sample attributed higher weight in children more strongly to diet and low levels of physical activity than they did genetics (e.g., Sikorski et al., 2012). Dietary intake and physical activity are frequently considered to be within child/familial control, whereas genetics is not. Previous research has reported that stronger dietary and physical activity causal attributions for higher child weight is associated with more negative and stigmatising attitudes, again in keeping with controllability beliefs about weight (Elran-Barak & Bar-Anan, 2018; Mata and Hertwig, 2018). Our findings also reflected these patterns: child-focused weight stigma was positively correlated with dietary and physical activity weight attributions and negatively correlated with genetic weight attributions. However, in the current sample we did not find that endorsement of diet/physical activity as a cause of higher child weight predicted categorisation patterns once genetic attributions had been included in the model, potentially indicating the primacy of biological/genetic explanations as an attitudinal determinant.

A novel finding, in keeping with initial hypotheses, was that participants who more strongly attributed child weight to genetic causes were *less* likely to categorise higher weight figures in line with centile-based categories, compared to participants with weaker genetic attributions. Previous research suggests that individuals who attribute higher weight to biological and/or genetic causes also oppose stigmatising weight-related practices (Joslyn & Haider-Markel, 2019). We suggest that this may extend to an unwillingness to assign potentially stigmatising centile-based weight category labels (Dutton et al., 2010). Participants who had lower genetic attributions were therefore more likely to categorise higher weight figures in line with centile-based categories. This potentially contributes to our understanding of the association between adult labelling of higher weight in children and negative physical and psychological consequences. Individuals who are less likely to accept the established finding that weight is strongly genetically determined (e.g., Silventoinen et al., 2016) may be more willing to assign stigmatising labels to higher weight children and concomitantly more willing to behaviourally stigmatise. Notably, participants with lower genetic attributions were also more likely to categorise stimuli in category 2 as belonging to category two – this was not the case for lower weight (category 1) stimuli. We tentatively speculate that these individuals are also more willing to assign a 'healthy' label to a child based on perceived weight status, reflecting an endorsement of popular perspectives that conflate weight and health (e.g., Jackson et al., 2022).

Broadly in keeping with these findings, and with the initial hypotheses, participants who expressed lower levels of child-focused weight stigma were *less* likely to categorise some higher weight figures in line with centile-based categories (a significant difference was detected for category 3, but only a trend towards significance was found for category 4 stimuli). Unexpectedly, we also found that these individuals' judgements for stimuli depicting a *lower* BMI were less coherent with the centile-based categories. A growing body of research suggests that weight labelling of people, including youth, with higher weights can induce many of the negative psychological consequences of weight stigma (Hunger & Tomiyama, 2014; Pont et al., 2017; Puhl & Suh, 2015). It is logical to infer those participants with lower levels of child-focused weight stigma are more reluctant to assign categories which are implicitly linked with a number of pejorative assumptions about individuals on the basis of their size. Our findings tentatively indicate that this unwillingness to categorise feasibly extends to figures with lower weights. Future research should directly ask participants about the extent to which they find categorisation of child weight acceptable to further explore this idea. This finding suggests a possible mechanism for the established link between assignment of higher weight labels to children and negative health and psychosocial consequences: individuals more likely or willing to assign these descriptors appear to have higher levels of weight bias, which is associated with a wide range of negative consequences for the target (in this case, children with higher weights).

Our data strongly suggest that individuals who report stigmatising and blaming beliefs about child weight are also most likely to assign centile-category congruent descriptors. This calls into question key, foundational assumptions of existing child weight surveillance programmes that aim to promote centile-category congruent labelling – notably, the assumption that individuals who assign such descriptors based on perceived weight status have an appropriate and beneficial perspective on child weight. It underlines the vital importance and urgency of research that evaluates alternative approaches to health promotion and communication with families about child health, such as weight-inclusive approaches (Hunger et al., 2020). Weight inclusive approaches centre wellbeing rather than objective weight status as the lens through which to view child health. The current study contributes to an accumulating body of evidence suggesting that public health narratives and initiatives that conflate weight and health and encourage weight categorisation based on this premise have the potential to cause significant harm to people with higher weights, including some of the most vulnerable: children.

4.4. Strengths, limitations, and suggestions for future research

A key strength of this study is that it combined questionnaire-based and categorisation data with eye-movement measurements to examine child weight decision-making from multiple perspectives. It brought together research literatures from several different disciplines – public health, psychophysics, and weight stigma – to attempt to critically challenge previously untested assumptions around the extent to which patterns of judgements about child weight are controllable and specific to parents. These assumptions implicitly underpin most previous research in the area and indeed underpin the public health policies and interventions that draw on it. It is also the first study, to our knowledge, to try to mechanistically examine which specific attitudes and beliefs might be involved in increasing the risk of negative consequences to children categorised by adults as having a higher weight.

An important limitation of the study is the use of stimuli that exclusively depict white children, categorised by a participant population that almost exclusively reported white British ethnicity. The ethnic composition of stimuli (based on 3D body scans of white children) and sample reflected the population from which both were drawn in North East England, an area in which almost 96% of inhabitants report white ethnicity (Office for National Statistics, 2020). However, this limits the generalisability of our findings to other, more ethnically diverse populations. It also underlines the importance of future work with non-white samples using stimuli based on body scans of children in other ethnic groups: it is necessary to develop such stimuli from scratch, based on a new database of 3D scans, because body composition shows important differences by ethnicity (Nightingale et al., 2011; Nightingale et al., 2013). To this end, recruitment of samples of children from other ethnic backgrounds to this ongoing research is currently underway elsewhere in the UK.

Another study limitation is the recruitment of primarily undergraduate and postgraduate students. Whilst this was invaluable in demonstrating for the first time that perceptual and attitudinal factors affect categorisation for a sample primarily composed of non-parents, it could not specifically tell us about the possible mechanisms and potential harms of parental categorisation, which is itself the key focus of current public health work. A future study should recruit a more ethnically- and gender-diverse sample of parents with children of the relevant ages i.e., the adults towards whom current public health campaigns about child weight are currently directed, to examine whether similar relationships of categorisation with causal weight attributions and child-focused weight stigma are observed.

4.5. Conclusions

In this study, we sought to critically examine processes and core assumptions underlying current weight normative approaches to weight surveillance and parent feedback for child health promotion. We documented for the first-time basic patterns of looking and categorisation for adults' child weight judgements in a general population sample. We found that unconscious, unalterable perceptual biases appear to significantly influence categorisation patterns for higher weight bodies, and we established that these biases affect adult observers as a whole, regardless of parental status. We found that key attitudinal factors - lower genetic attributions for child weight and higher child-focused weight bias – tended to predict more frequent assignment of higher weight labels to higher weight stimuli. Overall, our findings clearly contradict the idea that parents are uniquely 'poor' at weight categorisation, because our general population sample showed the same categorisation patterns. They also contradict the idea that categorisation patterns can be easily changed via educational or behavioural interventions, because perceptual biases are not easily amenable to alteration (see, e.g., Harrison & Backus, 2014). Finally, they suggest that individuals who exhibit the behaviour actively encouraged by numerous ongoing public health campaigns - i.e., assigning higher weight category descriptors to children with higher weights - may hold more stigmatising beliefs about child weight. This could help explain why children considered by adults to have a higher weight experience a range of deleterious outcomes compared to children not considered to have a higher weight as a direct consequence of weight bias; moreover, it indicates that efforts to induce labelling of higher weight risk increasing the stigmatisation experienced by children with higher weights. Weight inclusive approaches to child health are urgently needed to offer viable, non-stigmatising alternatives that do not depend upon erroneous assumptions about parents and about the underlying process of weight categorisation itself, and do not pose a risk to children's wellbeing. Perceptual biases in category judgements cannot be changed, but stigmatising attitudes towards children with higher weights absolutely can and should be challenged.

CRediT authorship contribution statement

Elizabeth H. Evans: Conceptualization, Methodology, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Martin J. Tovée:** Conceptualization, Methodology, Data curation, Writing – review & editing. **Peter J.B. Hancock:** Formal analysis, Writing - review & editing. **Piers L. Cornelissen:** Data curation, Formal analysis, Writing - original draft, Writing - review & editing.

Data availability

Data will be made available on request.

Declarations of interest

None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.bodyim.2022.11.001.

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