**Abstract**

*Introduction:* Age has been found to moderate the relation between cognitive biases and psychopathology, yet little is known about normative age-related change in these biases during adolescence. Adolescence might be a key developmental period for changes in negatively biased information-processing, and understanding the trajectories of these processes in a typically developing population is a pre-requisite for further comprehending their association with psychopathology.

*Methods:* This study explores the effect of age on seven cognitive biases in a diverse community sample from the United Kingdom (*N* = 540) aged 10 – 17 years (309 were female) using self-report measures.

*Results:* Age demonstrated a positive linear association with three biases: threat interpretation, negative attributions and overgeneralizing scores.

*Conclusions:* Important changes take place during adolescence that may increase young people’s negative cognitive biases. Empirical data on normative age-related changes in cognitive biases should be integrated into theoretical models of biased information-processing and psychopathology.

*Keywords:* Cognitive bias; Threat interpretation; Attributional bias; Overgeneralizing; Adolescence.

Cognitive biases play a crucial role in the maintenance and development of emotional psychopathology in young people (e.g. Orchard, Pass & Reynolds, 2016a; Platt, Waters, Schulte-Koerne, Engelmann & Salemink, 2017). These constructs form a focus during cognitive restructuring as part of cognitive behavioural therapy (CBT) for a wide range of mental health problems in young people. According to Beck’s (1976) cognitive model of depression, negative cognitive biases are characterized by evaluations of one’s environment that are biased towards a pessimistic view of the self, the world and other. These biased evaluations occur when an individual attends to negative or potentially threatening stimuli in their environment while overlooking positive or neutral information (Beck, Emery & Greenberg, 1985; see Table 1 for definitions).

Few previous studies have explored the normative development of cognitive biases during adolescence. Although, recent research demonstrates that adolescents internalize peer rejection and do not exhibit the same self-protective biases as adults do when faced with evaluative threats (Rodman, Powers & Somerville, 2017). Change during adolescence might be predicted given ongoing development in relevant cognitive and social-cognitive functioning and associated neural bases (Kilford, Garrett & Blakemore, 2016). For example, metalizing and perspective-taking have been shown to develop during adolescence (e.g. Dumontheil, Apperly & Blakemore, 2010), while related brain regions such as medial prefrontal cortex and temporoparietal junction undergo structural and functional change (Mills, Lalonde, Clasen, Giedd & Blakemore, 2014). Ongoing neurocognitive development has also been observed during adolescence in socioaffective processes of relevance to cognitive biases, including empathy (Decety & Michalska, 2010) sensitivity to peer rejection (Sebastian, Viding, Williams & Blakemore, 2010; Steinberg & Morris, 2001), and attributing emotional meaning to social stimuli (Nelson, Leibenluft, McLure & Pine, 2005; Crone & Dahl, 2012). These data suggest ongoing development in the way adolescents process and interpret information, particularly in a social context. It is therefore perhaps surprising that few studies have examined age-related changes in cognitive biases during adolescence.

**Negative Cognitive Biases in Adolescence**

Research exploring cognitive biases in youth have tended to focus on the relation between individual biases and specific psychiatric diagnoses, with age serving as a moderating factor in the relation between cognitive biases and emotional psychopathology. For example, personalizing and catastrophizing were more strongly associated with self-reported anxiety as age increased in a clinic-referred sample (Weems, Berman, Silverman & Saavedra, 2001). Cannon and Weems (2010) reported that negative cognitive biases significantly predicted diagnostic status of anxiety for clinic-referred adolescents (12-17 years) but not children (7-11 years). Salient changes in cognitive processing throughout childhood and adolescence may influence the relation between children’s anxiety symptoms and cognitive biases (Weems, Berman, Silverman and Saaveda, 2001).

Age has also been found to moderate the link between threat interpretation bias and anxiety. Threat interpretation is characterized by the tendency to interpret ambiguous situations and stimuli as threatening. Adolescents (13-16 years) with an anxiety disorder have been found to choose more threatening interpretations of ambiguous events than adolescents without an anxiety disorder; a pattern not found in the child groups aged 7 to 9 years. (Waite, Codd & Creswell, 2015). The relation between threat interpretation and anxiety has also been analyzed longitudinally in a community sample of 10 - 11 year olds, and results suggest that the relationship strengthened over time (Creswell & O’Connor, 2011). The authors reasoned that cognitive biases might act as a risk factor for psychopathology as cognitive styles become more stable with increasing cognitive maturity.

Research has also shown that a negative attributional style may confer vulnerability to the development of depression (Abela, 2001; Runyon & Kenny, 2002). One study has shown that it is not before the age of 14 or 15, that individuals’ causal attributions interact with stressful life events to predict an increase in depression (Cole et al., 2008). Therefore, age may play a moderating role in the link between attributional style and the emergence of depression. However, it is currently unclear whether there are normative developmental changes in attributional style during adolescence: uncovering such changes may have implications for attribution theory.

Overall, independent findings from studies exploring different cognitive biases mirror each other in that several biases appear to be increasingly related to psychopathology as young people enter adolescence. This suggests there may be an important developmental change occurring during adolescence. To fully understand how age might moderate the relation between biases and psychopathology, it would be helpful to explore if there exist age-related changes in the endorsement of biases in a normative sample. Given the social context of many cognitive biases, normative changes may reflect more global social-cognitive development, and thus it might be fruitful to understand age-related changes that occur in the absence of mental health difficulties.

**The Present Study**

The aim of the current study was to explore the effects of age on seven cognitive biases in an adolescent sample including: threat interpretation, negative attributions, personalizing, selective abstraction, mind reading, overgeneralizing and underestimation of ability to cope (Table 1). These were chosen to cover a range of cognitive biases that have been found to be associated with mental health symptoms (Maric & Heyne, 2011; Waite, Codd & Creswell, 2015; Cole et al., 2008). For this reason, psychopathology symptoms were a possible confound, and therefore externalizing and internalizing difficulties were also measured. Given research suggesting protracted social cognitive development during adolescence, and findings from the literature demonstrating associations between emotional symptoms and cognitive biases that increase with age during this time, a significant positive association between age and each of the seven biases was predicted. We also explored whether a quadratic model would better fit the data, given theories of non-linear social and affective development during adolescence (e.g. Casey, Jones & Hare, 2008). In light of data demonstrating emerging sexual dimorphism in prevalence rates of psychopathology associated with biases, particularly during adolescence (Altemus, Sarvaiya & Epperson, 2014), we also examined whether there may be increasing rates of biases with age in females but not males.

**Method**

**Participants and Procedure**

Data are reported for a community sample of 540 adolescents (309 were female) with a mean age of 14.13 years (SD = 1.75, range 10–17 years). Participants were recruited across two secondary schools a sixth form college (schooling for 16-18 years) and two primary schools in London and Surrey, UK. Schools were opportunistically sampled following initial contact with approximately 20 schools in London and Surrey. Of the students who took part in the research, the mean percentage of missing data across all analyses was 3%. Data for ethnicity were missing for 24 participants (4%). Of the remaining 516 participants, 29% were White British, 25% Bangladeshi, 21% British Asian, 8% Black British, 7% Asian Other and 6% Other. These figures are representative of the ethnic diversity in Tower Hamlets, London where the majority of data were collected. Data from the Department of Education (2015) showed that the five schools ranged from “high” to “low” compared to national averages in terms of the percentage of students eligible for free school meals (an index of deprivation). Thus, the sample was both ethnically and socially diverse.

Data collection took place over two sessions, typically one week apart, and involved completing a fixed order battery of self-report questionnaires in a class environment under exam conditions. Cognitive bias measures were completed during the first session and the psychopathology measure was administered during a second session. Ethical approval was granted by the university Research Ethics Committee. Informed consent was obtained from all individual participants included in the study. Parental consent was obtained for participants under 16 years of age and informed participant consent was obtained for all respondents.

#### Measures

Three self-report measures of cognitive biases and one screening measure of psychopathology were administered. Demographic information was collected on a separate questionnaire completed by the participants, and maternal education (secondary, further, higher) was used as a categorical measure of socio-economic status (Entwisle & Astone, 1994).

 **Children’s Negative Cognitive Errors Questionnaire-Revised** **(CNCEQ-R).** The CNCEQ-R (Maric, Heyne, Van Widenfelt & Westenberg, 2011) has 16 items measuring underestimating ability to cope (UAC), personalizing, selective abstraction, overgeneralizing and mind reading on a five-point scale. Participants are given descriptions of hypothetical situations, which are followed by a statement in the form of a thought about the situation. One item asks the respondent to imagine they are giving a talk in front of their class and a few classmates suddenly start laughing. This vignette is followed by the thought: “They think I’m doing a bad job”. Participants are then asked to rate the extent to which the thought represents how they would think if experiencing that situation. The measure has demonstrated acceptable construct validity (Weems, Berman, Silverman, Saavedra, 2001) and the internal consistency in the current sample was adequate (α=.83).

**Children’s Attributional Style Questionnaire-Revised** **(CASQ-R).** The CASQ-R (Kaslow & Nolen-Hoeksema, 1991) is a 24-item questionnaire that measures internal-external, stable-unstable and global-specific attributions of negative situations. A sample internal-external item is: “A good friend tells you that he or she hates you.” Participants choose between the following explanations of the situation: “My friend was in a bad mood that day” or “I wasn’t nice to my friend that day”. The measure has shown good criterion-related validity and Cronbach’s alpha in the current sample was .56, which is in line with previously reported alphas (Thompson, Kaslow, Weiss & Nolen-Hoeksema, 1998).

**Ambiguous Scenarios Questionnaire-child version (ASQ-C).** The ASQ-C (Barrett et al., 1996) presents participants with 12 ambiguous situations followed by a threatening and a non-threatening interpretation of the scenario. Respondents are asked which one they think is most likely. One item describes a situation where you hear a big crash in the house at night and participants choose between the following interpretations: “Someone has dropped something on the floor” or “One of your parents has fallen and is hurt”. Internal consistency was adequate (α=.89).

**Strength and Difficulties Questionnaire (SDQ).** The SDQ (Goodman, 1997) comprises 25 items measuring externalizing and internalizing difficulties over the past six months. Responses are coded on a three point scale including “Not True”, “Somewhat True” and “Certainly True”. A sample item is “I worry a lot.” Good reliability and validity has been widely reported for the SDQ (Goodman, 2001). The scale demonstrated adequate internal consistency for the internalizing and externalizing subscales (αs=.71 and .72, respectively).

**Results**

Analyses were performed using SPSS software (v. 23.0). Tables 2 and 3 displays correlations among variables and the means and standard deviations of each variable by age and sex respectively. Separate regression analyses were performed to examine the effects of age on seven cognitive biases. Familywise error rate was controlled for by Bonferroni correction. To adjust for multiple comparisons for seven biases the alpha level for the models was set at *a* = .007. Age (in months) was mean centered and both age and age2 were entered as predictors with each bias score entered as the dependent variable. Table 4 contains the standardized coefficients for both the linear and quadratic predictors for each of the seven biases. A significant linear association was observed between age and threat interpretation, negative attributions and overgeneralizing, while regression equations for mind reading, underestimating ability to cope, personalizing and selective abstractions were not significant, with neither linear nor quadratic trends with age observed.

**Adjusted Analyses**

To assess the full age range across adolescence, participants were necessarily recruited from primary (ages 10-11), secondary (11-16) and sixth form (16-17) educational settings, reflecting the structure of the local education system. Since different age groups were recruited from different schools, this allowed for the possibility of confounding cohort effects. Indeed, the SES proxy of maternal education differed significantly by school, χ2(12) = 48.46, *p* < .001, as did internalizing SDQ scores, *F*(3, 530) = 7.66, *p* < .001. There were no significant differences in externalizing SDQ scores by school, *F*(3, 530) = 2.37, *p* = .07, and correlations among age and internalizing/externalizing SDQ scores were not significant (*r* = .07, *p* = .10 and *r* = .04, *p* = .42, respectively). However, for completeness, adjusted scores were used for both psychopathology (including internalizing and externalizing symptoms as separate variables) and socio-economic status in follow-up analyses.

Three hierarchical regressions (presented in Table 5) demonstrated that while both internalizing and externalizing scores were significantly related to threat interpretation, negative attributions and overgeneralizing, age contributed to significant additional variance in each case after correcting for multiple comparisons (*p* < .017).

To adjust for the potential confounding effects of socio-economic status three hierarchical regression analyses were conducted to test the incremental contribution of age on threat interpretation, negative attributions and overgeneralizing bias after adjusting for mother’s level of education (secondary, further, higher). Data for maternal education was only available for a subsection of the sample (*N* = 265). Results are displayed in Table 6 and indicate that age was still a significant predictor for all three biases when including maternal education in the model, although this was no longer significant for threat interpretation following Bonferroni correction.

**Effects of Gender**

To investigate potential effects of gender, the relation between age and the threat interpretation, negative attributions and overgeneralizing was tested separately for males and females with alpha set at *a* = .008 to correct for six comparisons. The effect of age on all three biases was only significant (following correction) for females, *F*(1,303) = 10.42, *p* = .001, *R2* = .03, *R2*Adjusted = .03.

Given potential gender differences, we subsequently compared the slopes for the two genders directly, using an age\*gender interaction term. Three hierarchical regression analyses were conducted for threat interpretation, negative attributions and overgeneralizing with age (mean centered) and gender added into the model first and the interaction term added second. However, interaction terms for all three biases were not significant.

**Discussion**

The current study is the first to provide data on cross-sectional age-related changes in seven cognitive biases across adolescence. Age had a positive linear effect on threat interpretations, negative attributions and overgeneralizing between 10 and 17 years. Analyses adjusting for psychopathology and maternal education as a proxy for socio-economic status showed that age contributed to significant additional variance in these three biases. Following correction, this was no longer significant for threat interpretation, possibly due to reduced power as we had data on maternal education for a subsection of our sample. Additionally, while exploratory analyses suggested age effects may be stronger in females than males, age and gender did not interact to predict these biases in the full sample.

Age effects observed in the present study are likely due to developmental changes. Developmental factors are likely to be multifactorial, although one cognitive system that could be driving the relation between age and negative biases are the developmental changes in social cognition that occur during adolescence. Clearly maturation in social-cognitive abilities allows for a more complex and integrated understanding of the social world and facilitates more complex social relationships with others (Nelson, Leibenluft, McLure & Pine, 2005), but becoming proficient in such tasks may also give rise to increased sensitivity to negative social stimuli and the negative information-processing of ambiguous stimuli (Sebastian, Viding, Williams & Blakemore, 2010). Further, young people may be more likely to interpret ambiguous social stimuli as negative or threatening because of increased sensitivity to peer acceptance and rejection during adolescence (Platt, Kadosh & Lau, 2013).

Separable developmental factors may also at least partially underlie the age-related changes in each specific cognitive bias seen in the present study. In terms of negative attributions, one speculative hypothesis arises from previous research that found that negative cognitions emerge as a consequence of negative life events (Turner and Cole, 1994; Mezulis, Hyde & Abramson, 2006). Although negative life events were not measured in the current study, older adolescents have reported a greater number of negative life events involving peers, school and family than younger adolescents (Larson & Ham, 1993) and future research might explore how the experience of negative life events may in part contribute to the increasing negative attribution scores across adolescence. Similarly, overgeneralizing involves making assumptions about future events or situations, and thus relies heavily on the individual’s tendency towards future thinking and making significant links between past and future experiences of a given situation. Adolescents have been shown to exhibit developmental gains in abstract thought and reasoning regarding future events (Gott and Lah, 2014). It could be that developmental gains in young people’s ability to represent their future drives age-related gains in overgeneralizing bias. Future research could test this hypothesis by exploring the link between negative life events, future-focused thinking and increases in negative cognitive biases in typically developing adolescents.

More broadly, pubertal and social maturation during adolescence (Forbes & Dahl, 2010) may also drive changes in negative information processing. Hormonal changes during puberty has an organizational effect on brain development and has been associated with patterns of psychopathology (Sisk & Zehr, 2005). The age effects observed in the current study are likely driven by a complex combination of social, biological and cognitive maturation during adolescence.

Understanding developmental changes in cognitive biases across adolescence has clinical implications for cognitive-behavioral therapies (CBT) that aim to change unhelpful thinking patterns and biases and encourage more balanced thought processes. CBT is one of the most prevalent therapeutic models available for young people due to its substantial evidence base (Das et al., 2016). An important task for the CBT therapist is to consider whether the young person’s presenting cognitive style is within expected normal variations of development or whether it represents a significant deviation from the expected developmental trajectory (Stallard, 2005). However, to date little is known about the normative development of cognitive biases leaving clinicians without evidence-based norms with which to understand the young person’s thinking styles. These findings offer preliminary data on the age effects of cognitive biases for clinicians to support their interventions. Additionally, normative data on age-related changes in cognitive biases might be useful for researchers hoping to understand deviations from typical development.

The next step for research exploring developmental norms in cognitive biases might include the exploration of longitudinal trends. Furthermore, it might be fruitful to examine whether experimental methods of measuring cognitive biases correspond with the self-report data presented here. For example, the homophone spelling task (e.g. Richards, Reynolds & French, 1993) involves listening to homophones (e.g. “die” or “dye”) and spelling out either the threatening or nonthreatening interpretation. However, existing experimental paradigms tend to measure a more general negative or threatening interpretation bias (e.g. Haller, Raeder, Scerif, Kadosh & Lau, 2016; Orchard, Pass & Reynolds, 2016b) rather than specific biases such as mind reading or overgeneralizing negative events. A weakness of the adolescent research in this area is the limited number of cognitive bias measures that explore several different types of cognitive biases making it difficult for researchers to explore multiple cognitive biases simultaneously. It is clear from the current study that exploring several cognitive biases together using an amalgam of measures has revealed age-related patterns across biases that might have otherwise been overlooked if biases were explored singularly. The relation among these biases (see Table 2 for correlations) and the common developmental factors that might drive these age-related changes could be an interesting focus for future research.

The findings discussed in this study need to be considered in light of some limitations of the current investigation. First, the study relied on self-report assessment of both cognitive biases and psychopathology without triangulation by clinical assessment. We further recognize that conclusions drawn from cross-sectional analyses of age also require support through longitudinal research. Additionally, owing to the structure of the local school system, it was necessary to recruit participants of different ages from different schools, allowing for the possibility of confounding cohort effects. However, we believe this is unlikely to account for the findings presented, as measures of socio-economic status and psychopathology (which differed between some of the schools tested) were accounted for in the adjusted analyses, and age effects were still significant. Age was not correlated with internalizing symptoms in our sample, which seems to contradict previous data showing an increase in depressive symptoms in females in early adolescence (NHS Digital, 2018). Given that anxiety and depression symptoms are combined in the internalizing subscale of the SDQ, it could be that our measure lacked sensitivity to pick up on any developmental changes specific to depression in females.

The current study examined normative age-related changes in several cognitive biases during adolescence. Age exhibited a positive linear effect on threat bias, negative attributions and overgeneralizing scores with the remaining biases showing no change across adolescence. Despite the importance of cognitive biases for explaining the cognitive underpinnings of psychopathology and informing treatment (Beck, 1976), little research had examined how these thinking patterns develop across adolescence, a key period of change in terms of social functioning and brain development (Kilford, Garrett & Blakemore, 2016). Our data provide an important first step in addressing this question.

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