

Department of Psychology

15 June 2021

Eva Telzer, Associate Editor
Social Cognitive and Affective Neuroscience
SCAN-21-056

Dear Dr. Telzer,

Thank you for the thoughtful feedback contained within your decision letter dated March 15th, 2021 and the opportunity to resubmit our manuscript (SCAN-21-056). We have revised our manuscript in accordance with the reviewer comments and organized those changes in the appended document. All comments are numbered and organized by reviewer and gravity, for ease of identification. Both clean and tracked-change copies of our manuscript are included with this most recent submission.

We believe that our revision addresses all concerns cited by the reviewers and has certainly increased the quality of the manuscript. Of course, if there are any questions or concerns, please do not hesitate to contact me. Again, we appreciate both your time and the time of the reviewers and we look forward to your assessments of this most recent version of our manuscript.

All the best,

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Reviewer 1 Feedback:

Major Comments

1. “The paper would benefit from a clearer and more thorough review of prior literature on emotion development. There is a large literature on how children develop an understanding of specific emotions (Harris, Pons, Russell, Widen, Casey, Hoemann/Xu/Barrett, Nook/Somerville) that should be synthesized for readers to better situate the current findings in prior literature. Right now, readers are left with the vague impression that “behavioral evidence suggests that emotion representations change across age” without a more specific description of current thinking on how exactly they change. I know word limits can be tight, but greater clarity on prior research seems important for interpreting these neural results.”

Our response: This criticism has been duly noted and our introduction has been amended with a more thorough review of the developmental literature on affect and emotion (Lines 81 – 98). In brief, readers are presented with a summary of studies highlighting that the expression and recognition of affective information is relatively simplistic early in life and develops more complexity with age, with development mediated by degrees of familial and peer emotional intelligence and language development. We do briefly touch upon differentiation models and what they suggest the developmental trajectory of emotional granularity to be.

2. “Relatedly, I was left wanting more support for specific neural hypotheses in the introduction. The authors have some very interesting interpretations of how the vmPFC contributes to emotion representation in the discussion (see also Satpute et al., 2017), and I think these ideas could be introduced earlier. This could replace much of the discussion of how RSA functions”

Our response: Much of the discussion on RSA has been removed; though, a review as to why an RSA approach constitutes a novel contribution for this subject does still have value for readers in framing the niche this study is attempting to fill (Lines 128 – 141). Some of the literature supporting our neural interpretations has been moved to the introduction (Lines 121 – 127); namely, the vmPFC’s role in affective evaluations and emotion classification: “*Late prefrontal development may be crucial to affective development in other ways, too, as the vmPFC has been tied to neural signatures of emotion classification in adults (Saarimaki et al., 2016), which may support research finding children have underdeveloped emotion differentiation skills relative to adults (Pons, Harris, & de Rosnay, 2004). Changes in classification may actively shape neural representations within the mPFC, as well as the amygdala and ventral anterior insula (Satpute et al., 2016).*”

3. “In my opinion, a major threat to the study’s logic is that the results might not be “about” emotion, as they could instead be driven by some other variable in the negative/positive videos. This is especially concerning given that the pos/neg videos included actual characters, whereas the neutral videos did not. The authors mention this in the limitations section, but to be honest to their methods, I think it should be discussed more openly, potentially shifting their study’s framing to something like: “representations of affective social scenes become more differentiated from childhood to adulthood.”

Our response: The authors appreciate the point being made here and have made some accommodations. More references to the role that social factors play in emotional development have been noted (Lines 82 – 88; 147; 524 – 528; 538- 540). We have also inserted a brief aside highlighting that social and affective factors may be highly confounded (Lines 196 – 203). However, we are hesitant to fully reframe the experiment as limited strictly to affective social scenes. While the degree of socially relevant content may have been balanced by valence category, the degree of sociality present in any one clip varied, such that to characterize all clips as demonstrating at least a moderate degree of social content may not be appropriate. One could make the argument that the presence of even one human’s, or even anthropomorphized animal’s, face constitutes a baseline degree of social relevance, but then one would be hard-pressed to find examples of empirical studies in the emotion literature that are devoid of a social component. Of

course, we do welcome reviewers to view the stimuli that have been shared in our Google Drive [See Manuscript – Page 27] to better determine whether they share our conclusion.

4. “Relatedly, I didn’t fully follow the authors’ logic with their neutral video control analysis... How does this analysis show that the result is specific to affect? A crucial contrast showing that similarity scores for neutral videos are equal between children and adults (suggesting that similarity scores only change across age for affective videos) is not reported, and beyond that even this analysis doesn’t address the fact that neutral and pos/neg images differ in ways beyond just whether or not they are affectively charged (e.g., the inclusion of characters). So the logic here could be better articulated for readers. In fact I might suggest running just one omnibus ANOVA in which pos/neg/neu videos are all included in the main analysis. You can then show that there is a significant interaction such that pos/neg are represented more similarly than neu videos and that they also change more over age than neu videos.”

Our response: This criticism is well placed and we have incorporated neutrally valenced stimuli in our ANOVA models (Lines 330 – 333; 371 - 384), as well as outlined more details related to our neutral stimuli (Lines 214 – 217; 242; 292) and their limitations as controls (Lines 529 – 546). Consequently, we removed the supplementary materials entirely and also incorporated our age-related control analysis within Section 3.0 Results as well (Lines 338 – 352). Because neutral videos were similar to valenced videos in most regards except valence, their reduced pattern similarity functioned relative to valenced videos functioned to demonstrate in a very basic sense that these affective regions seemed to be responding to affective information. We had relegated this analysis to the supplementary section because it was auxiliary to the narrative of differences between valences, but do now recognize that including neutral videos in the primary analysis and results provides a much more statistically coherent approach.

5. “Another logical concern with the current paper that is left unaddressed is the fact that the authors discuss ‘emotion’ representation when all they do is examine representations categorized by ‘affective valence’ (i.e., negative, positive, neutral). Constructionist approaches (Barrett, 2006, 2017) distinguish between ‘emotion’ (a conceptualized instance of a specific emotion) and ‘affect’ (broader senses of valence/arousal that can be parsed into a specific emotion through conceptualization) but the current paper doesn’t really dive into what this means for their findings. Is the implication that adults tend to construct their reactions to the negative videos in terms of several discrete negative emotions (e.g., “anger,” “disappointment”) but children seem construct their emotional responses in terms of a more valence-general concept of “bad” or “negative”? Such an interpretation accords with Nook et al., 2017, and although this explanation is hinted at, it is not explicitly stated.”

Our response: The original framing of measuring emotion was an oversight that should have been corrected prior to submission. Unfortunately, given the limited sample size and the design of the stimuli set, our analyses are not suited to explore emotional granularity at a level more precise than affective-valence categories. As such, many references to overt emotion throughout the paper have been walked back to more general statements of valence (e.g., Lines 135; 142; 161; 243; 245). This lack of resolution is highlighted as a limitation in section 4.1 Study Limitations (Lines 533 – 545). Additionally, our discussion has been amended to more explicitly state that our interpretation of the findings accords with previous research you’ve highlighted (Lines 473 – 482): *“Relatedly, our ability to consider the multidimensionality of affect-related concepts improves with age as well, which could logically lead to greater idiosyncratic processing. This may speak to our age-related valence findings, as adults likely defaulted to representing emotional information continuously, rather than strictly categorically (See Satpute et al., 2016). It’s relevant to cite Nook and colleagues again, as they had found that affective complexities like valence and arousal were a function of age (Nook et al., 2017; 2018). As such, our conceptions of affective experiences may evolve over development from notions relatively faithful to valence-general lines (i.e., “good”, “bad”) to representing a more nuanced, multidimensional understanding of affective experiences”*

6. “Similarly, there is no interpretation of the finding that negative scenes were represented more similarly than positive scenes. I think this is an interesting finding that accords with research on how differentiation

of negative emotions is thought to be more important for mental health than differentiation of positive emotions (O'Toole et al., 2020), but more could be said about it."

Our response: We had originally cut valence-related discussions for space limitations but have since reintegrated them, per your suggestion (Lines 483 – 494): *"While adults did demonstrate lower levels of similarity in response to valence than children, it's notable that the correlation was not non-existent. As a result, valence likely still plays a role in shaping some aspects of decision-making and behavior and may explain the findings like those suggesting greater homogeneity in response to norm violations of negative affect than positive affect, with targets who express positive or neutral responses to negatively perceived stimuli to be judged as less authentic (Krumhuber & Manstead, 2009), socially appropriate, and less liked (Ansfield, 2007), as well as punished more harshly than incongruent responses to differently valenced stimuli (Szezurek, Monin, and Gross, 2012). These findings support previous suppositions regarding an information value asymmetry between positive and negative affective experiences, as negative information may signal a need for adjustment to avoid detrimental consequences (O'Toole et al., 2020; Pratto & John, 1991)."*

Minor Comments

1. "The first sentence of the abstract is quite vague (how do emotions change?) and there's a typo in the 2nd sentence."

Our response: The abstract has been amended to add more specificity (Lines 25 – 31): *"Developmental studies have identified differences in prefrontal and subcortical affective structures between children and adults, which correspond with observed cognitive and behavioral maturations from relatively simplistic emotional experiences and expressions to more nuanced, complex ones. However, developmental changes in the neural representation of emotions have not yet been well explored. It stands to reason that adults and children may demonstrate observable differences in the representation of affect within key neurological structures implicated in affective cognition"*

2. "The first sentence of the intro is a little grand... Don't we have strong feelings as adults? In fact, some researchers (Casey, Larson) would offer evidence that emotions are more intense in adolescence than adulthood..."

Our response: This sentence has been removed from the manuscript and the corresponding closing statement has been amended to better reflect the findings of the study (Lines 567 - 570): *"Although it may be natural as an adult to pine for the relative simplicity with which we assessed our childhood experiences, our findings suggest these might be necessary trade-offs in the development of mature, nuanced understandings of our emotional experiences."*

3. "Please specify what was considered "excessive head motion""

Our response: Section 2.5 Pre-Processing has been corrected to more precisely define head motion cut-off criteria (Lines 270 – 274): *"Excessive head motion TRs were identified using the FSL Motion Outlier tool, which defines outlier thresholds as the 75th percentile plus 1.5 times the interquartile range. If more than 15% of TRs were considered outliers or if head motion values for any of the three rotations were greater than 1.5mm, participants were excluded from analyses."*

4. "The control analysis arguing that negative and positive videos were similarly "extreme" in their portrayal of negative and positive expressions could be stated more clearly (i.e., it's not clear what you mean by "absolute emotional valence")."

Our response: We have expanded our explanation of the stimuli assessment process to emphasize that ratings were collected on a second-by-second basis, and statistical analyses were used to demonstrate that they significantly differed in valence, but not magnitude (Lines 204-214): *"... As should be expected, positive and negative clips significantly differed in emotional valence [$t(14) =$*

16.88, $p < 0.001$], with positive clips receiving an average second-by-second affective score of 0.89 and negative clips receiving an average affect score of -0.76. There were no significant differences in the absolute value of these scores by valence [$t(14) = 1.38$, $p = 0.19$], suggesting positive and negative clips were appropriately matched in time spent displaying categorically congruent valenced information (Karim & Perlman, 2017)."

5. "Please include a figure showing the brain region masks"

Our response: Brain region masks have been visualized within Figure 2.

6. "Tables 1 and 2 use > instead of < for p values."

Our response: This was an oversight on our part and has been corrected. Thank you!

7. "I'm not sure you can have Fig 6 if the 3-way interaction is not significant"

Our response: We had originally included the figure in the interest of transparency, with the rationale being that some readers might benefit from a visual representation of the relationship (however insignificant), but do now acknowledge that this is not standard practice. As such it has been removed, along with figures formerly labeled Figure 2 & Figure 3, in accordance with the modification of our primary analyses (The inclusion of neutral stimuli in our primary ANOVAs demanded that the relationship be visualized using plots of the interaction (Figures 3 & 4) and not main effects).

8. "Hoemann, Xu, & Barrett (2019) and studies by Nook et al. could enrich hypotheses for why emotion representations become more dissimilar across age on p. 18 (e.g., development of language)."

Our response: Our discussion has been amended to include the suggested supporting literature (Lines 468 – 482) and connect it with our interpretations of the findings: *"Similar mechanisms have been theorized by other researchers (e.g., Pons et al., 2003) and such a postulation fits nicely with rational constructivist-related theories of emotional development, in which humans start with proto-conceptual primitives to emotion which mature over time due to language and symbol learning, Bayesian inductive learning, and constructive thinking mechanisms (Hoemann, Xu, & Barrett, 2019; For a review, see Fedyk & Xu, 2018). Relatedly, our ability to consider the multidimensionality of affect-related concepts improves with age as well, which could logically lead to greater idiosyncratic processing. This may speak to our age-related valence findings, as adults likely defaulted to representing emotional information continuously, rather than strictly categorically (See Satpute et al., 2016). It's relevant to cite Nook and colleagues again, as they had found that affective complexities like valence and arousal were a function of age (Nook et al., 2017; 2018). As such, our conceptions of affective experiences may evolve over development from notions relatively faithful to valence-general lines (i.e., "good", "bad") to representing a more nuanced, multidimensional understanding of affective experiences."*

9. "Brooks & Freeman also provide nice citations for last sentence of paragraph on p 18 about how conceptual similarity and RSA could be connected. Relatedly, is there evidence in the emotion decoding studies (Wager et al.) that could guide interpretation of how vmPFC vs NAcc/Amygdala contribute to specific emotion representations?"

Our response: We incorporated the referenced study from Brooks & Freeman (2018) to support the notion that studies of representational similarity have demonstrated coherence with conceptual similarity (Lines 497-501): *"Work from Brooks & Freeman (2018) does suggest coherence between self-reported conceptual similarity and representational similarity in emotion perception, which supports claims connecting RSA findings to ecologically valid phenomena, however, future work relating differences in representational similarity to the accrual and modeling of affective experience is needed."*

10. “I might recommend more classic citations for appraisal theory in the discussion (e.g., Ortony, Clore)”

Our response: This recommendation has been duly noted and incorporated into the discussion on appraisal theories (Lines 462 – 468): *“Appraisal theories of emotion broadly posit that emotions are elicited by or are emergent phenomena from evaluations of events and circumstances (Roseman & Smith, 2001; Ortony, Clore, & Collins, 1988; Clore & Ortony, 2008). These evaluations may be colored by the biases and information individuals already possess. It may be the case that the greater potential for experiential variance inherent to having had lived longer may add nuance or variation to adult representations relative to children.”*

11. “Do you have any data on what discrete emotions these videos induce in children or adults? This would help address the affect v emotion distinction mentioned above.”

Our response: The original framing of measuring emotion was an oversight that should have been corrected prior to submission. Unfortunately, given the limited sample size and the design of the stimuli set, our analyses are not suited to explore emotional granularity at a level more precise than affective-valence categories.

12. “The limitations section could be expanded to include other potential threats to the conclusion that differences in representational similarity are due to age: (e.g., ages differing in brain structure/volume, movement, interpretation/meaning of videos)”

Our response: Section 4.1 Study Limitations has been modified to include a discussion of age-related head motion concerns (Lines 505 – 509), age-related structural and functional differences (Lines 509 – 515), and interpretations of videos (Lines 540 – 544). Additional limitations were added highlighting the imperfect nature of our neutral control stimuli (Lines 529 – 546) and the limited resolution in our analyses regarding emotion classification (Lines 547-559).

Reviewer 2 Feedback:

Major Comments:

1. “In the preprocessing section the authors state that “individual TRs were identified and adjusted for if greater than 15% of TRs were considered outliers, or if head motion values for any of the three rotations were greater than 1.5mm.” This raised a few questions for me. What does it mean that individual TRs were identified and adjusted (how)? How were outliers defined?”

Our response: Section 2.5 Pre-Processing has been amended to reflect that outliers were defined based on excessive head motion (*See next comment for more details*) and were adjusted for within regression models (Lines 266 – 270): *“We identified head motion and noise-related factors by using timeseries data extracted from white matter and CSF, six head motion parameters, and their first derivatives to calculate and threshold metric values of how each time point was motion-affected. Additionally, individual TRs were identified and regressed out based on excessive head motion.”*

2. “Were there other motion cutoffs? (e.g., a participant was excluded entirely if a given % of TRs had to be adjusted due to being outliers, or because values exceeded a specific threshold e.g. on framewise displacement) The methods section notes that 12 participants were excluded due to excessive head motion but it’s not clear how that was defined.”

Our response: Section 2.5 Pre-Processing has been corrected to more precisely define head motion cut-off criteria (Lines 270 – 274): *“Excessive head motion TRs were identified using the FSL Motion Outlier tool, which defines outlier thresholds as the 75th percentile plus 1.5 times the*

interquartile range. If more than 15% of TRs were considered outliers or if head motion values for any of the three rotations were greater than 1.5mm, participants were excluded from analyses.”

Minor Comments:

1. “The authors note that they are not aware of any literature exploring changes in mPFC-NAcc connectivity during development. It would be nice to incorporate findings from Fareri et al 2015 (NeuroImage) here.”

Our response: We appreciate the reviewer’s suggestion. Research from and related to Fareri et al., 2015 has been incorporated into the discussion in Lines 442 through 451 to further enrich the discussion of mPFC-NAcc connectivity: *“While mPFC-VS resting state functional connectivity demonstrates a positive relationship from childhood through early adulthood, whether connectivity increases with age (Di Martino et al., 2008, 2011) or remains stable through development (Fareri et al., 2015; Greene et al., 2014) is debated. The magnitude of task-based functional connectivity between mPFC and VS also appears to be variable dependent upon the task-based context (Richards et al., 2013), though, age-related linear increases have been observed for positive incentives (van der Bos et al., 2012). Regardless of potential changes in connectivity, it may be the case that the connection between VS and vmPFC serves a stimulus evaluation role (Fareri et al., 2015; Bartra et al., 2013; Salzman et al., 2007) which may modulate value-related signals relevant to affectively valenced stimuli. ”*

2. “-p 6: “close the gap” felt overstated – I’m not sure one study can really close a gap, and especially since this study does not include adolescents, more work will be needed to fully understand developmental differences.

Our response: We’ve toned down that overstatement with the following modification (Lines 141 – 143): *“Thus, the aim of this research is to further our understanding of developmental differences in affective representation using more modern methodology.”*

3. “-p 5: “However, this may not be true for young children, as vmPFC-amygdala connectivity strengthens across normative development, only reaching adult-like patterns of functional connectivity around age 10 (Gee et al., 2013).” Though negative connectivity was evident after age 10, connectivity was still weaker than in adults (in other words, valence was consistent into adulthood starting around age 10, but magnitude/strength of connectivity continued to change). It would be helpful to revise this sentence a bit to more accurately reflect that connectivity was not yet adult-like at that point / during adolescence.”

Our response: This section has been altered to correct for the unintentional misrepresentation (Lines 112- 115): *“However, the quality of the relationship between these structures may be different for young children and adults, as mPFC-amygdala connectivity alters from positive to negative around age 10, with the valenced association in regional activation strengthening across normative development (Gee et al., 2013).”*

4. “-p 20: “where children are more similar in that they have perhaps had comparable levels of exposure to the swath of emotional situations the world has to offer.” While I appreciate the overall point, this stood out to me since there is of course substantial variability in exposure to emotional situations within children (e.g., literature on stressful life events). Perhaps the authors could revise this to say “more comparable”?

Our response: In incorporating suggested research from the reviewers and attending to criticisms from Reviewer 1 requesting a more detailed discussion of the supporting neural literature in the introduction, the section previously containing this line was deconstructed and rearranged (now approximately Lines 416 – 424). Perhaps the closest analogue to the reviewer-highlighted statement (which we believe now meets the recommendation) in the current version is contained in Lines 452-456: *“Taken together, a potential interpretation of our findings is that, in light of the region’s role in processing of emotional stimuli, the pattern and response similarities we find in children may signal their shared, relatively-limited experience of the vast array of potential*

affectively-relevant experiences, while adults respond more divergently to novel affectively-valenced information by referencing a wider berth of past evaluations.”

5. “-p 12: “All ROIs were thresholded at 50%.” I think this only refers to amygdala and NAcc since they were defined using the probabilistic atlas, whereas vmPFC was not? Perhaps specify amygdala and NAcc instead of saying “all.”

Our response: This oversight has been amended, now stating on Line 285: “*Amygdala and NAcc ROIs were thresholded at 50%*”

6. “-I think this is just a formatting issue with the PDF but the legends for figs 5/6 appeared missing but then showed up in the supplement. The letter notation for the affiliations in the supplement was also off.”

Our response: In accordance with reviewer suggestions, we’ve removed some figures (formerly Figure 2, Figure 3, Figure 6) in order to more accurately represent our findings. All remaining figures have their corresponding legends on a separate page following the figure, as per submission guidelines. Reviewer 1’s well-directed criticisms of our supplemental analyses resulted in our supplemental materials being incorporated into the primary manuscript. As a result, we no longer have a supplemental title page.