IMPROVING LITERACY:

PAIRING AFFECTIVE WITH COGNITIVE INTERVENTIONS

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ABSTRACT OF THE DISSERTATION

Improving Literacy: Pairing affective with cognitive interventions

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Reading is a critical skill, with lack of reading proficiency related to poor outcomes including poverty, unemployment, and incarceration rates. Poor reading skill can occur for multiple reasons. Research on the brain basis of reading problems typically focuses on issues with letter-sound mappings, but much less work has been done on the equally critical issues of what kinds of feedback are most effective for learning these mappings; and what other kinds of challenges, including environmental ones, can disrupt this process. In particular, stressors prevalent in low-income urban communities, such as exposure to violence, affect neural activity, thereby interfering with the cognitive processes involved in learning. Despite the prevalence of violence in urban communities and coinciding low literacy rates, research assessing the neural effects of violence, and examining specific reading interventions targeted at these neural differences, is quite limited. The first goal of the following research was to determine what makes for effective orthography-phonology (spelling-sound) training. Novel letter strings are trained with Elaborative Feedback, which we expected to promote cognitive processing by pairing content-specific information with an affective component. In Study 1, novel letter strings trained with Elaborative Feedback, compared to feedback containing only content-specific information (Content Feedback) and to that containing only affective information (Positive Feedback), resulted in the highest performance accuracy. This

Elaborative Feedback condition was also associated with activation in the ventromedial prefrontal cortex (vmPFC), implicated in reward-processing, as well as neural regions implicated in orthography-phonology mapping, such as the posterior middle and superior temporal and supramarginal gyri. Therefore this study revealed both which type of feedback was most effective for learning novel word forms, and the neural mechanisms behind its effectiveness. The second goal was to enhance the effectiveness of orthography-phonology training specifically for individuals exposed to urban stressors. Study 2 revealed differential resting state functional connectivity (rsFc) by childhood exposure to violence among neural regions implicated in both the affective and cognitive components of feedback processing. Individuals exposed to high levels of violence in childhood had decreased rsFc between the vmPFC and the amygdala, as well as the right dlPFC and other neural regions implicated in working memory, such as the intraparietal sulcus (IPS). Study 3 tested whether exposure to violence during childhood and reading ability moderate the effectiveness of feedback type. Individuals with high reading ability and who were exposed to increasing levels of violence during childhood benefited more from EF. This research provides cognitive neuroscientific evidence that could ultimately inform the integration of affective with cognitive skills in urban schools, possibly helping to improve performance and close the achievement gap.

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INTRODUCTION

Literacy is a critical skill, particularly in the current information age, and is linked to positive social, health, and financial outcomes. However, despite years of research on effective instructional methods, many individuals remain illiterate or lack proficiency in reading skills. In particular, relative to the general population, individuals with dyslexia as well as those adversely affected by environmental stressors, such as those associated with low socioeconomic status (SES), have higher rates of illiteracy and reading impairment (e.g. Barbarin et al., 2006; Sirin, 2005). Research demonstrates a variety of stressors related to low socioeconomic status, as well as cognitive, affective, and neural effects of such stressors, which likely explain this achievement gap. For example, children from poor quality neighborhoods characterized by crime, abandoned buildings, and drugs, had reduced pre-reading readiness skills, even after controlling for socioeconomic status (Barbarin et al., 2006). Moreover, the effects of such stressors include not only reading-specific differences, but also differences in reward and threat processing. Given these findings, it is plausible that pairing affective with academic interventions may improve learning outcomes for individuals affected by such stressors.

Significance

The following research has the potential to offer neuroscientific evidence of an effective reading intervention—one that engages neural mechanisms implicated in both reading and reward. Concurrent activation of task and reward-related regions may be relevant to struggling readers, who often have negative affective responses to reading due to difficulties they have experienced. Further, this research provides evidence of neural differences associated with exposure to violence, thus calling for academic interventions which capitalize on such differences. While these differences are commonly viewed as "deficits," this research suggests that the effects of urban stressors have potential to be adaptive, given proper interventions. Lastly, the successful use of elaborative feedback for individuals exposed to high levels of violence, who also have high reading ability, offers preliminary evidence for integrating affective with cognitive skills in urban schools. Such an approach could ultimately help with improving performance and closing the achievement gap.

Literature Review

Reading Model

Learning to read requires a variety of skills, including both domain-general, such as working memory, as well as domain-specific processes such as orthographic (visual word form) to phonological (auditory word form) conversion (Goff, Pratt, & Ong, 2005; Tighe, Wagner, & Schatschneider, 2015). The Simple View of Reading posits that reading skill is simply a product of decoding, or orthography-phonology mapping, and linguistic comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). However, a more recent model developed by Tighe et al. (2015), the multiple indicator multiple indicator cause (MIMIC) model, demonstrates additional significant predictors of reading comprehension, which is understood to be the ultimate goal of learning to read (Cain & Oakhill, 2007). These additional predictors include verbal and nonverbal reasoning, and working memory. Orthography-phonology conversion, however, is shown to be the strongest predictor of reading comprehension during early elementary school, prior to third grade (Diakidoy, Stylianou, Karefillidou, & Papageorgiou, 2005; Verhoeven & van Leeuwe, 2008). Because orthography-phonology processing has been shown to be an essential early literacy skill, the following research capitalizes on this basic literacy skill.

However, despite the MIMIC explaining 73-87% of the variance in reading comprehension (Tighe et al., 2015), and the Simple View of Reading explaining about 40-80% (Hoover & Gough, 1990), a significant portion of reading comprehension ability remains unexplained. Thus, it is important to consider additional factors, including affective factors such as motivation and/or stress-induced cognitive deficits. One study, for example, showed that perceived confidence in reading predicted word reading ability (Cartwright, Marshall, & Wray, 2016), and the subjective value of reading predicted reading comprehension (Cartwright et al., 2016). As such, it is important to address not only domain-specific reading skills, but also to incorporate an affective component in reading interventions.

The following research emphasizes orthography-phonology processing, an essential domain-specific literacy skill, yet also incorporates affective processes that may promote reading. Although this research does not specifically address reading comprehension, orthography-phonology processing is presumably a critical step in ultimately comprehending written text.

Orthographic-Phonological Conversion

Multiple skills are required for efficient reading, as demonstrated for example by the MIMIC (Tighe et al., 2015) model; yet reading instruction, especially at the early stages of reading, generally focuses on orthographic to phonological conversion. In the field of education, this skill is called “decoding” and has been defined as the ability to use individual letters and combinations of letters (graphemes) to access phonemes (elementary sound units of a word) to compute the overall sound form of the word (Vellutino, Scanlon, & Spearing, 1995). During the early stages of learning to read, children learn grapheme-phoneme (“b” - /b/) mappings and then learn to blend phonemes to form words (/b/ - /a/ - /t/). As reading progresses, these associations become automatic, and children learn to segment words into syllables (Lesch & Martin, 1998), and blend the syllables together to form whole words. More advanced readers tend to apply this strategy (Orsolini, Fanari, Tosi, De Nigris, & Carrieri, 2006), and do so more automatically as reading proficiency increases (Morais, 2003).

Several lines of evidence have converged on the consensus that instruction in grapheme-phoneme correspondences is crucial for learning to read. A meta-analysis found that instruction that systematically teaches grapheme-phoneme correspondences and how to blend them to form words was highly effective compared to interventions that teach students to read whole words (Ehri, Nunes, Stahl, & Willows, 2001). Such systematic instruction was also more effective than whole-language approaches, where grapheme-phoneme correspondence is taught unsystematically, such as when the need arises in the context of a story (Ehri et al., 2001). Grapheme-phoneme conversion and syllabic analysis approaches have been found to be effective across multiple studies. For example, training first graders to read words at the phoneme (“b—a—t”) and at the onset-rime (e.g. “b—at”) level, where the onset is the initial consonant or consonant cluster and the rime is the following vowel and consonants, was more effective than training at the whole-word level (“bat”; Haskell, Foorman, & Swank, 1992), suggesting that segmenting words is an effective strategy. Children who received instruction that taught them to decode words by comparing them to other similar words (“bat” - “hat”) with additional instruction in grapheme-phoneme analysis improved more than children receiving instruction without the additional grapheme-phoneme analysis (Ehri, Satlow, & Gaskins, 2009). Adolescents taught to segment words into syllables, compared to those taught to read whole words without such segmentation, showed greater improvements in reading and spelling novel words (Bhattacharya & Ehri, 2004). In the current research, we use an orthography-phonology training paradigm, which teaches and reinforces word segmentation and blending of syllables to form words.

Regarding reading problems, research suggests that impaired orthographic-phonological conversion underlies the reading difficulties experienced by individuals with dyslexia (Harm & Seidenberg, 1999; Lyon et al., 2003; Shaywitz & Shaywitz, 2005) and other reading impairments (Vellutino, Fletcher, Snowling, & Scanlon, 2004; Vellutino et al., 1995). Instruction aimed at teaching orthography-phonology conversion has been found to be highly effective for struggling readers. For example, Williams (1980) demonstrated the effectiveness of explicit training in phonological processing to children with learning disabilities by providing such training over a 2 year period in New York City classrooms. In another study, training aimed at teaching poor readers to segment words into syllables improved reading speed with trained pseudowords and for untrained words, indicating generalization of the skill (Wentink, Van Bon, & Schreuder, 1997). Tressoldi, Vio, Iozzino (2007) found that teaching children with dyslexia to recognize syllables within words was more effective than other methods based on phonemic awareness, assisted reading, and other exercises.

Despite improvements in performance, many individuals with dyslexia have persistent reading difficulties (Gabrieli, 2009; Shaywitz et al., 1999; Torgesen, 2006), and the achievement gap persists, with students from low socioeconomic backgrounds continuing to average lower reading test scores than their peers from high socioeconomic backgrounds (Barbarin et al., 2006; Lee & Burkam, 2002; Sirin, 2005). One possibility is that affective reactions to the experience of difficulty in reading tasks may contribute to the persistence of literacy problems. For example, such difficulty may lead to low confidence in one's ability (Dweck & Bempechat, 1983) and feelings of helplessness (Dweck, 1975). This could result in low motivation and less time spent reading, further interfering with reading progress. Therefore, incorporating feedback that promotes positive affect as well as relevant cognitive skills may help improve outcomes for these individuals. It has been suggested that researchers as well as educators should seek to improve motivation in addition to reading skill among poor readers, given the correlation between motivation and skill level (Morgan & Fuchs, 2007). In the Studies 1 and 2, we pair training in orthography-phonology mapping with relevant feedback, with the aim of enhancing the effectiveness of reading instruction due to recruitment of both affective and cognitive processes.

The neural correlates of orthography-phonology conversion

Reading novel letter strings aloud is expected to activate neural systems associated with orthography-phonology conversion. On the orthographic side, the left ventral occipito-temporal cortex (vOT), part of the fusiform gyrus, is often referred to as the “visual word form area” (VWFA; Dehaene & Cohen, 2011). Damage to this region has been shown in numerous studies to be associated with pure alexia (Binder & Mohr, 1992; Damasio & Damasio, 1983; Leff et al., 2001), a selective deficit in processing visual input for words that leaves other functions such as writing intact. In healthy participants, activity in this region has been shown to increase for processing letter sequences with increasing in similarity to English (Binder, Medler, Westbury, Liebenthal, & Buchanan, 2006) and French orthography (Vinckier et al., 2007), suggesting that this area responds to letter combinations. Thus, studies of participants with and without brain damage seem to converge to support a role for the left vOT in orthographic processing.

Neural regions implicated in phonological processing include the left posterior superior temporal gyrus (pSTG; Graves, Grabowski, Mehta, & Gordon, 2007; Graves, Grabowski, Mehta, & Gupta, 2008; Price, 2012; Rumsey et al., 1997). Evidence includes modulation of activity in the pSTG by exposure to pseudowords, with decreasing activation for pseudowords the more they are heard and repeated (Graves et al., 2008), suggesting that this region is recruited for processing the phonological form of the word. Phonological processing is also impaired in conduction aphasia, and the pSTG was shown to be the only area of overlap between damage leading to conduction aphasia and activation for healthy participants in phonological tasks (Buchsbaum et al., 2011).

Converting orthography to phonology has been shown to involve the left supramarginal (SMG) and posterior middle temporal (pMTG) gyri. Previous studies have shown that damage to the left SMG impairs mapping between phonology and orthography (Alexander, Fischer, & Friedman, 1992; Roeltgen, Sevush, & Heilman, 1983). A functional neuroimaging study that manipulated word characteristics found that activity in the SMG was associated with decreasing bigram frequency, or the frequency with which two letters co-occur (Graves et al., 2010). Such findings suggest this region may be recruited for converting orthography to phonology.

Struggling readers demonstrate differences in neural activation during reading tasks, especially in regions implicated in spelling-sound mapping. One study found that second graders with dyslexia, compared to typical readers, failed to show specialization of the fusiform gyrus for letters compared to symbols (Maurer et al., 2007), suggesting lack of specialization of this region in dyslexia. Meta-analyses have also found that struggling readers underactivated the MTG, STG, and SMG compared to typical readers (Maisog, Einbinder, Flowers, Turkeltaub, & Eden, 2008; Richlan, Kronbichler, & Wimmer, 2009).

Since the current studies involve learning with feedback, we note that research has demonstrated improvements in reading performance following remediation, with corresponding increases in relevant neural regions. Specifically, increases in activity in the left temporo-parietal cortex have been shown to be correlated with improvements in reading (Eden et al., 2004; Temple et al., 2003).

While research demonstrates activation of these left-lateralized regions during reading tasks, as well as the relationship between such activity and successful reading, no studies to our knowledge have demonstrated recruitment of regions implicated in orthography-phonology mapping during the receipt of instructional, content-based feedback. Thus, we aimed to determine whether these areas were recruited during feedback. We predicted that instructional, content-based feedback (referred to here as content feedback, CF), as well as feedback that was both rewarding and content-based (referred to here as elaborative feedback, EF), would recruit prominent areas of the reading network, including the left MTG, STG, SMG, and vOT.

Increasing activation in these task-relevant regions during the receipt of positive feedback has the potential to enhance activity in such regions for struggling readers, thereby bringing neural activity more closely in line with that of typical readers. Evidence of neural activation in task-relevant regions during the receipt of feedback would provide a basis for the use of such feedback in the classroom, with the aim of benefiting struggling readers.

Domain-general processing effects

Reading aloud has been shown to recruit regions implicated in orthography-phonology conversion to varying degrees, depending on the word characteristics as well as domain-general task demands. First, in a study that carefully controlled for effects of word characteristics, reaction time was found to modulate activity in the task-positive network (Graves et al., 2010). This network consists of regions activated during tasks that require focused attention (Fox et al., 2005), including the inferior frontal junction (IFJ), inferior parietal lobule (IPL), ventral occipito-temporal cortices (vOT), dorsal-lateral and ventral prefrontal regions, and supplementary motor area (SMA). Specifically, activity in regions including the precentral gyrus and inferior frontal gyrus was correlated with slower reaction time (RT; Graves et al., 2010), implicating these regions in domain-general task-positive conditions that require attention and working memory. Further, in that study, low frequency words, or words that occur less frequently in the English language, recruited regions implicated in orthographic processing, such as the bilateral fusiform gyri, and in orthography-phonology conversion, such as the left MTG, as well as general task-positive regions such as the left IFJ (Graves et al., 2010).

High frequency words recruited regions that are implicated in semantic processing, such as the posterior cingulate (pCing) and angular gyrus (AG; Graves et al., 2010), but are also part of the default-mode-network (DMN). This is a network of neural regions typically active during passive conditions and includes the AG, pCing, MTG, anterior temporal lobes, and dorsomedial prefrontal cortex (PFC; Buckner, Andrews-Hanna, & Schacter, 2008; Gusnard, Raichle, & Raichle, 2001). While activation in such regions for high frequency words has typically been attributed to semantic processing, some of our recent research has demonstrated that activation in such regions may instead be due to difficulty effects due to word characteristics (Graves, Boukrina, Mattheiss, Alexander, & Baillet, 2017). Similarly, we have also shown that domain-general processing demands—in particular, difficulty of discriminability between words and pseudowords in a lexical decision task—co-locate with semantic processes in areas of the DMN (Mattheiss, Levinson, & Graves, in press). Together, these studies suggest that under conditions in which lexical processing is less difficult, the task-positive network will be activated to a lesser degree, with a corresponding increase in the task-negative or DMN. In contrast, under conditions in which lexical processing is more difficult, the task-positive network will show greater activation, with corresponding greater deactivation of the DMN.

In Study 1, although both elaborative and content feedback reinforce the spelling-sound skill by presenting auditory and visual information regarding the blending of the nonword, items trained with elaborative feedback are expected to be read with less recruitment of orthography-phonology and task-positive regions, suggesting these items are read with greater ease due to highly effective feedback. Reduced recruitment of such regions may afford more neural resources for higher level reading skills.

Feedback

Adverse affective reactions to the experience of difficulty in reading tasks may contribute to the persistence of literacy problems (Dweck, 1975; Dweck & Bempechat, 1983), resulting in low motivation and less time spent reading, thus further interfering with reading progress. Therefore, pairing an affective intervention (positive feedback) with relevant cognitive skills, specifically, with orthography-phonology (spelling-sound) conversion, may improve reading outcomes.

In particular, feedback, or information regarding one's performance, has been shown to enhance performance (Hattie & Timperley, 2007), engage affective processes such as motivation (Hattie & Timperley, 2007), and increase the likelihood of re-engaging in the task for which the learner received feedback (Deci, Koestner, & Ryan, 1999). Past research suggests that certain types of feedback are more effective than others, such as feedback that encourages self-regulation (Hattie & Timperley, 2007), provides specific information about the use of strategies in a task (Brinko, 1993), emphasizes and praises cognitive processes rather than the learner personally (Brinko, 1993; Kamins & Dweck, 1999), and emphasizes learning as compared to performance goals (Heyman & Dweck, 1992).

For example, one study that examined the effectiveness of feedback on a thermo-energy learning task found elaborative to be more effective than simple feedback (Lin, Atkinson, Christopherson, Joseph, & Harrison, 2013). In that study, participants were asked to engage in a computer-based content-learning task about thermodynamics, and then answer 12 multiple-choice questions. They received either simple or elaborative feedback from an animated agent. Simple feedback informed the learner about whether or not their answer was correct, while elaborative feedback additionally informed the learner about why their answer was correct or incorrect. Compared to simple feedback, elaborative feedback facilitated learning.

While extrinsic rewards such as providing learners with candy upon answering correctly may actually have negative consequences for learning, feedback in the form of praise has been shown to be rewarding and promote learning (Hattie & Timperley, 2007). It has been suggested that extrinsic rewards may reduce one's sense of responsibility for learning and thus interfere with motivation (Deci et al., 1999). Feedback that informs the learner of the skills successfully applied in a learning task, however, is likely to be intrinsically rather than extrinsically rewarding, thus effectively increasing motivation and a sense of responsibility for one's learning.

Neural activation for feedback processing

The large-scale neural network associated with reward processing has been shown to include the ventromedial prefrontal cortex (vmPFC), dorsal striatum (caudate and putamen), ventral striatum, amygdala, and dopaminergic midbrain (for reviews see O'Doherty, 2004; Smith & Delgado, 2015). Given that positive feedback is rewarding (Hattie & Timperley, 2007), it is expected to modulate activity in these regions. The dorsal striatum, for example, was comparably activated during the receipt of performance feedback, as well as during reward and punishment outcomes on a card-guessing task

(Tricomi, Delgado, McCandliss, McClelland, & Fiez, 2006), thus demonstrating its role in processing feedback and extrinsic reinforcers. Further research has shown activation of the striatum for conditions in which an outcome is contingent on an action, thus suggesting that it may be recruited for processing reinforcement of action due to a reward, rather than the reward itself (O'Doherty, 2004; Tricomi, Delgado, & Fiez, 2004). Likely due to its role in reward-based learning, activity in the striatum during feedback learning may also be related to subject performance, with activity in the striatum correlating with subject performance and adjustment of their responses due to feedback (Vink, Pas, Bijleveld, Custers, & Gladwin, 2013). Lastly, there is evidence that the striatum, as well as the amygdala, may respond to reward prediction, activating prior to the receipt of the reward (for review, O'Doherty, 2004).

The vmPFC has been implicated in encoding reward value (Blair et al., 2006; for review, Smith & Delgado, 2015), including expected monetary outcomes (Knutson, Fong, Bennett, Adams, & Hommer, 2003) and social rewards (Somerville, Kelley, & Heatherton, 2010). In one study, participants with low, but not high, self-esteem showed increased activity in this region for positive compared to negative social feedback (Somerville et al., 2010), suggesting a role for the vmPFC in evaluating the salience of a social reward. The vmPFC has also been shown to be recruited for self-processing, likely due to its role in assigning value to self-related concepts (D'Argembeau, 2013). For example, this region was recruited for processing evaluative feedback (e.g. "You're a great girl!"; Pan, Hu, Li, & Li, 2009).

Despite such research, we are aware of no studies that have examined the neural activation responsible for the effectiveness of content plus reinforcement-based feedback, referred to here as elaborative feedback (EF). We test its potential to enhance learning by engaging task-relevant as well as reward-processing regions. Activation of regions implicated in orthographic and phonological processing during receipt of feedback may be particularly important for struggling readers, given that these individuals demonstrate differences in activation of such neural regions during reading tasks (Maisog et al., 2008; Richlan et al., 2009). Moreover, concurrent activation of task-relevant and reward regions, such as the vmPFC and caudate, may enhance the learner's associations between reward and application of the target skill, thus addressing both cognitive and affective impediments to reading.

The use of feedback for individuals exposed to urban stressors

Previous research has demonstrated modulation of feedback effects by individual differences and environmental conditions. For example, when teachers communicated high standards as well as assurance in the student's ability, performance improved, especially among stereotyped students, with greater effects for African American compared to White students; further, this effect was greater for African American students with low levels of school trust (Yeager et al., 2014). Some studies have demonstrated differential use of feedback after stress compared to neutral conditions, with one study showing that participants learned less from negative feedback after a stress-inducing task (Petzold, Plessow, Goschke, & Kirschbaum, 2010). Specifically, participants were less successful in learning to avoid stimuli paired with negative feedback after the stress manipulation than in the control condition. The authors note that this finding is in line with research indicating an attentional bias away from negative information under stress

(Roelofs, Bakvis, Hermans, van Pelt, & van Honk, 2007). Individuals with low compared to high working memory skills have also been found to respond less positively to negative feedback (Schmeichel & Demaree, 2010); this is particularly interesting, given the stress-induced impairments in working memory.

Individuals have also been shown to differ on the degree to which they seek positive versus negative feedback For example, individuals with low compared to high self-esteem more inclined to seek positive self-evaluative feedback (Bernichon, Cook, & Brown, 2003).

Despite such findings, no studies to our knowledge have examined differential effects of feedback for individuals exposed to high compared to low levels of violence. Given previous findings on altered reward and threat processing due to acute and chronic stress, as well as decreases in connectivity between frontal and subcortical regions, individuals affected by exposure to violence may benefit more from positive, rewarding feedback than from negative or purely instructional feedback. Specifically, decreased regulation of subcortical emotion-processing regions indicates that these learners may be more responsive to the intrinsic rewards associated with feedback; and, further, may be less able to regulate adverse emotional reactions to threatening or punishing feedback.

Feedback that incorporates instruction, or task-relevant information, in a positive self-evaluative manner, may be particularly effective, with coactivation in task-relevant and reward regions also potentially enhancing the structure of white matter over time, as research suggests white matter may change as a function of neural coactivation (Damoiseaux & Greicius, 2009) and of learning (Fields, 2010; Takeuchi et al., 2010).

Finally, a slightly different line of research demonstrates that rewards can buffer against interference effects of negative stimuli (Padmala, Sirbu, & Pessoa, 2017; Yokoyama, Padmala, & Pessoa, 2015). For example, in one study, target stimuli trained with high compared to no reward, resulted in reduced interference effects from negatively valenced pictures on an attention task (Yokoyama et al., 2015). Given this experimental evidence, it is possible that individuals affected by the cumulative effects of negatively valenced distractors in their environment, such as a neighborhood with high rates of violence, may benefit from primarily positive rewards in order to buffer against the distracting effects of negative environmental stimuli. In Study 3, we test whether exposure to violence predicts higher performance on a literacy task for items trained with rewarding compared to nonrewarding feedback. This would suggest that positive feedback may buffer against the adverse effects of exposure to violence on learning.

The behavioral and neural effects of exposure to violence

Both behavioral and neuroscientific research offer insights into multiple factors contributing to the achievement gap between low and high-income children, including poor parental care (Hackman, Farah, & Meaney, 2010) and higher rates of exposure to physical and psychosocial stressors (Kim et al., 2013). Exposure to high levels of crime, particularly prevalent in low-income urban communities (Gillespie et al., 2009), serves as a source of chronic stress (Steptoe & Feldman, 2001). Further, mere exposure to violent events in one's neighborhood, even when they are not active participants in the violence, has detrimental effects (Clark et al., 2008; Sharkey, Schwartz, Ellen, & Lacoe, 2014; Sharkey, Tirado-Strayer, Papachristos, & Raver, 2012).

Exposure to violence is a pervasive problem, especially among urban communities plagued by high crime rates. Although there is research showing the neural effects of stress as well as low SES, little research has specifically examined the neural effects of chronic exposure to violence during childhood. Some studies have experimentally manipulated exposure to violence by using, for example, violent video games (Hummer et al., 2010; Hummer, Kronenberger, Wang, & Mathews, 2017), yet no studies to our knowledge have examined the effects of self-reported exposure to violence during childhood.

The deleterious effects of exposure to violence have also been found to have overlapping neural effects with that of other stressors. For example, urban youth exposed to trauma were found to have less amygdala-prefrontal functional connectivity (Thomason et al., 2015). An EEG study also showed that individuals exposed to trauma had differences in connectivity in frontal, temporal, and parietal lobes (Cook, Ciorciari, Varker, & Devillya, 2009), yet their EEG measure did not allow for more precise identification of which neural regions were involved. In Study 2, we use functional magnetic resonance imaging (fMRI) to locate specific neural regions where connectivity differs based on exposure to violence in childhood.

Exposure to stress

In Study 2, we examine the effects of exposure to violence during childhood and into early adolescence. Such exposure is a subset from the more general category of early life stress (ELS), defined as exposure to stressors such as abuse, neglect, or domestic violence during infant and child development. ELS has been shown to adversely affect both affective and cognitive processing (for a review see Pechtel & Pizzagalli, 2011).

Individuals who have experienced ELS typically report lower feelings of pleasure for rewarding stimuli, demonstrate differences in neural activity during reward anticipation (Dillon et al., 2009; Pechtel & Pizzagalli, 2011), and engage in higher levels of addictive behaviors (Pechtel & Pizzagalli, 2011).

ELS has been shown to affect perception of threat as well. Maltreated children in particular attend to threatening faces and show greater amygdala activity in response to threatening faces (Pechtel & Pizzagalli, 2011; Tottenham et al., 2011). Children who have experienced ELS also have a decreased ability to regulate negative emotional responses, resulting in impairments in goal-directed behavior in the presence of threatening stimuli (Malter-Cohen et al., 2013; Shackman et al., 2007; Tottenham et al., 2010). For example, compared to controls, children raised in orphanages showed a greater effect of negative distractor images in an Emotional Go-Nogo task, in which participants were asked to respond to target faces and inhibit their response when distracter faces appeared (Pechtel & Pizzagalli, 2011; Tottenham et al., 2010). Increased responsiveness to threat is thought to be related to decreased regulatory activity from the prefrontal cortex (PFC; Tottenham et al., 2011). The PFC has been shown to regulate threat and reward responses by influencing the amygdala, with increased amygdala activation corresponding to decreased PFC activity (for review, see Johnstone, van Reekum, Urry, Kalin, & Davidson, 2007; Martin, Laura N., Delgado, 2007; Ochsner, Silvers, & Buhle, 2012; Phelps, Delgado, Nearing, & LeDoux, 2004; Urry et al., 2006).This is supported, for example, by neuroimaging evidence from children who experienced ELS. During viewing of fearful faces, the participants showed decreased activity in the ventromedial PFC (vmPFC), as well as decreased coupling between the vmPFC and the amygdala (Tottenham et al., 2011). Similarly, stress manipulations have been shown to impair emotion regulation by decreasing functionality of multiple areas of the PFC, including the vmPFC, leading to decreased regulation of subcortical regions (Arnsten, 2009; Arnsten, Wang, & Paspalas, 2012).

There is evidence that ELS also affects executive functioning, including inhibitory control and working memory (De Bellis, Hooper, Spratt, & Woolley, 2009; Pechtel & Pizzagalli, 2011), along with neural activity in regions involved in executive functioning, such as the inferior prefrontal cortex (Mueller et al., 2010) and dorsolateral prefrontal cortex (Arnsten, 2009; McEwen & Morrison, 2013; Qin, Hermans, van Marle, Luo, & Fernández, 2009). Adults who experienced ELS performed worse on, and recruited more neural resources during, a working memory task (Philip et al., 2016).

Although these effects are widely demonstrated, understanding of the effects of such experiences at the level of neural circuitry remains limited (Pechtel & Pizzagalli, 2011). Some recent research, however, has begun to elucidate such effects. For example, children whose mothers reported high levels of perceived stress during their child's early years showed decreased functional connectivity between the lateral PFC and the right parahippocampal gyrus/ temporal cortex (Demir-Lira et al., 2016). Children who experienced early maternal deprivation have also been shown to have negative amygdala-medial prefrontal connectivity (Gee et al., 2013). Similarly, adolescent self-reports of trauma predicted less connectivity between the amygdala and prefrontal cortex (and also greater connectivity between the amygdala and limbic regions, Nooner et al., 2013).

These studies were conducted on children and adolescents, yet there is evidence that the effect of early life stress on amygdala-prefrontal connectivity persists even after the stressor is removed (Malter-Cohen et al., 2013). Thus, it is of interest to determine whether college age adults also demonstrate such effects of exposure to stress. In the current study, we address the effects of exposure to violence during childhood on adult neural connectivity. We examine differences in neural circuitry implicated in both regulation of the threat and reward response, and working memory, to help build a more comprehensive understanding of the effects of such exposure. Further, while much of the research on ELS focuses on stress during infancy, such as maternal deprivation, the current study assesses exposure to violence during the ages of 3 to 16. Overall, we aim to determine whether exposure to violence during childhood and early adolescence results in long-term differences in neural connectivity, particularly for areas thought to be related to aspects of feedback-based learning.

Socioeconomic Status

Exposure to violence is one of multiple factors that tend to co-occur with low socioeconomic status (SES). These include maternal deprivation, poor access to health care, and exposure to noise and toxins (McEwen & Gianaros, 2010). More generally, SES is thought to be a measure of a household's overall financial, employment, and educational levels (Mueller & Parcel, 1981). It has been suggested that stress and exposure to multiple risk factors such as those just described (Evans & Kim, 2010) mediate the widespread effects of low SES on affective and cognitive functioning. In line with these suggestions, the effects of SES largely overlap with the effects of other stressors, and include impairments in working memory, cognitive control, and language skills (Bickel, Moody, Quisenberry, Ramey, & Sheffer, 2014; Farah et al., 2006; McEwen

& Gianaros, 2010). Neural markers of SES are also similar to those of stress, with amygdala reactivity to threatening faces corresponding with perceived parental SES (Gianaros et al., 2008) and reduced activation in prefrontal neural regions (Hackman & Farah, 2009).

In Study 2, participant groups are matched on SES, yet they differ in exposure to violence during childhood; thus, we are in unique position to demonstrate whether exposure to violence, independent of SES, can affect neural circuitry.

Summary

Overall, the following studies aim to determine the neural basis for the effectiveness of feedback that is both rewarding and content-informative (Study 1); characterize neural connectivity among affective and cognitive networks involved in feedback processing, for individuals exposed to high compared to low violence (Study 2); and finally, examine differential effectiveness and subjective experience of feedback by exposure to violence (Study 3). In summary, the following studies should collectively demonstrate the importance of integrating affective and cognitive instructional techniques to enhance literacy, especially among individuals affected by high levels of violence.

STUDY 1

1.1 Aim

To identify the behavioral benefits and neural correlates of elaborative feedback when paired with an orthography-phonology (spelling-sound) mapping task.

While research demonstrates activation of specific neural regions for orthography-phonology conversion tasks, no studies to our knowledge have identified activation of such regions during the receipt of feedback. Further, behavioral research shows that feedback which is specific and emphasizes learning goals is more effective than more general forms of feedback, yet the neural correlates responsible for such effectiveness remain unclear.

Using brain imaging and behavioral methods, Study 1 examines the effectiveness of elaborative feedback (EF), which combines domain-relevant and reward-based components, compared to matched feedback containing either one alone. Based on the prediction that EF will be most effective, functional magnetic resonance imaging (fMRI) will help determine the source of the improvements, whether from orthography-phonology based processing, reward-based processing, or both.

1.2.1 Hypothesis 1

Elaborative feedback, compared to content and positive feedback, is expected to result in higher accuracy in reading aloud trained items.

1.2.2 Hypothesis 2

Elaborative feedback, compared to content feedback, is expected to recruit neural regions implicated in reward-relevant feedback, such as the striatum and ventromedial prefrontal cortex (vmPFC). Elaborative feedback, compared to positive feedback, is expected to recruit neural regions implicated in orthography-phonology conversion, including the pMTG, STG, SMG, and FG.

1.3 Methods

1.3.1 Participants

Twenty participants were recruited from the Rutgers University – Newark psychology undergraduate student participant pool, the Rutgers graduate student listserv, and Craigslist. One participant reported that he could not hear the feedback, and thus was excluded from the study, such that there were nineteen remaining participants. All participants provided written informed consent according to Rutgers University Institutional Review Board (IRB) guidelines. Participants were prescreened for no diagnosis of a learning disability, psychiatric, or neurological disorder. The average age of the sample was 24.3 years (SD=3.8), with a range of 19-32 years. Fourteen of the participants were female. The average (age-standardized) score on the Wechsler Test of Adult Reading (WTAR), an estimate of verbal intelligence quotient (VIQ; Wechsler, 2001), was 113 (SD = 10.49), where the population average is 100. All participants reported being native English speakers, indicating that they were exposed to English from birth. Four participants were bilingual. Participants were compensated for their time at $30 per hour.

1.3.2 Stimuli

Stimuli were selected from an existing, normed set of pseudoword stimuli (Gupta et al., 2004), which contains sets of pseudowords ranging from two to seven syllables. A relatively small number of pseudoword stimuli was chosen based on evidence from pilot testing that revealed that twelve to fifteen two-syllable pseudowords, each with multiple possible pronunciations, was a reasonable leaning task for participants in the given amount of time. The lower end of this range of the 12 to 15 pseudoword range was chosen since the task would be completed while participants were in the scanner, a novel learning environment with scanner noise.

Three lists of four two-syllable pseudowords, or pronounceable letter strings that are not real words, were selected (see Table 1) so as to control across lists for word characteristics. With word list as the independent variable, three one-way ANOVAs were conducted, yielding no significant differences between word lists in number of letters, $F(2,9) = 0.273$, $p > 0.05$, bigram frequency, $F(2,9) = 0.462$, $p > 0.05$ (Miller, Bruner, & Postman, 1954), or biphone frequency, $F(2,9) = 0.458$, $p > 0.05$ (two-phoneme combinations, analogous to bigram frequency; Vitevitch & Luce, 1998). Each list was paired with one type of feedback. The pseudoword list/feedback pairs were counterbalanced across participants, so that the type of feedback was paired with each pseudoword list for an equal number of participants. This was done as an additional control to ensure effects of feedback type were not confounded with pseudoword list.

List	A	B	C
Pseudowords	tesib tinabe desut kegide	terid botet kopise kedene	gilat bisob butib tosote
Bigram Frequency	0.006 (0.002)	0.008 (0.002)	0.007 (0.001)
Biphone Frequency	0.002 (0.002)	0.002 (0.001)	0.002 (0.001)

Table 1: The full set of pseudoword stimuli used in the study, selected from Gupta et al. (2004), and surface characteristics controlled across lists. Standard deviations are in parentheses.

Three types of feedback, provided only on correct trials, were compared in order to identify the influence of content and reward processing. Elaborative Feedback (EF) provides the learner with explicit information regarding the skill he/she applied (e.g., “Great! You blended po-tep”). Positive Feedback (PF; e.g., “Great! You got the answer correct”) provides positive reinforcement but no task-specific information. Content Feedback (CF; e.g., “It's always best to blend po-tep”) provides task-specific information without explicitly positive reinforcement. These conditions are illustrated in Figure 1. Auditory feedback in all three conditions contained exactly 8 syllables, and the duration was approximately 4 seconds. Auditory stimuli were recordings of a female voice with an American English accent. They were recorded using an Audio-Technica ATR-1200 Cardioid Dynamic Vocal/Instrument Microphone, plugged into a laptop computer recording using Audacity software. The feedback stimuli were matched across feedback conditions, as verified with feedback condition as the independent variable in each

ANOVA analysis. They were matched for duration (measured in milliseconds), $F(2,33) = 0.106$, $p > 0.05$, with EF $M = 3197$ ($SD = 152.8$), CF $M = 3197$ (SD=8.2), PF $M = 3199$ ($SD = 0$); average pitch, $F(2,33) = 0.748$, $p > 0.05$, with values of EF $M = 226.88$ Hertz (Hz; $SD = 3.8$), CF $M = 229.42$ Hz ($SD = 7.95$), PF $M = 228.09$ Hz (SD=0); and intensity, $F(2,33) = 0.531$, $p > 0.05$, with values of EF M = 76.47 decibels (dB; $SD = 1.45$), CF $M = 75.96$ dB (SD = 1.32), and PF $M = 76.14$ dB ($SD = 0$).

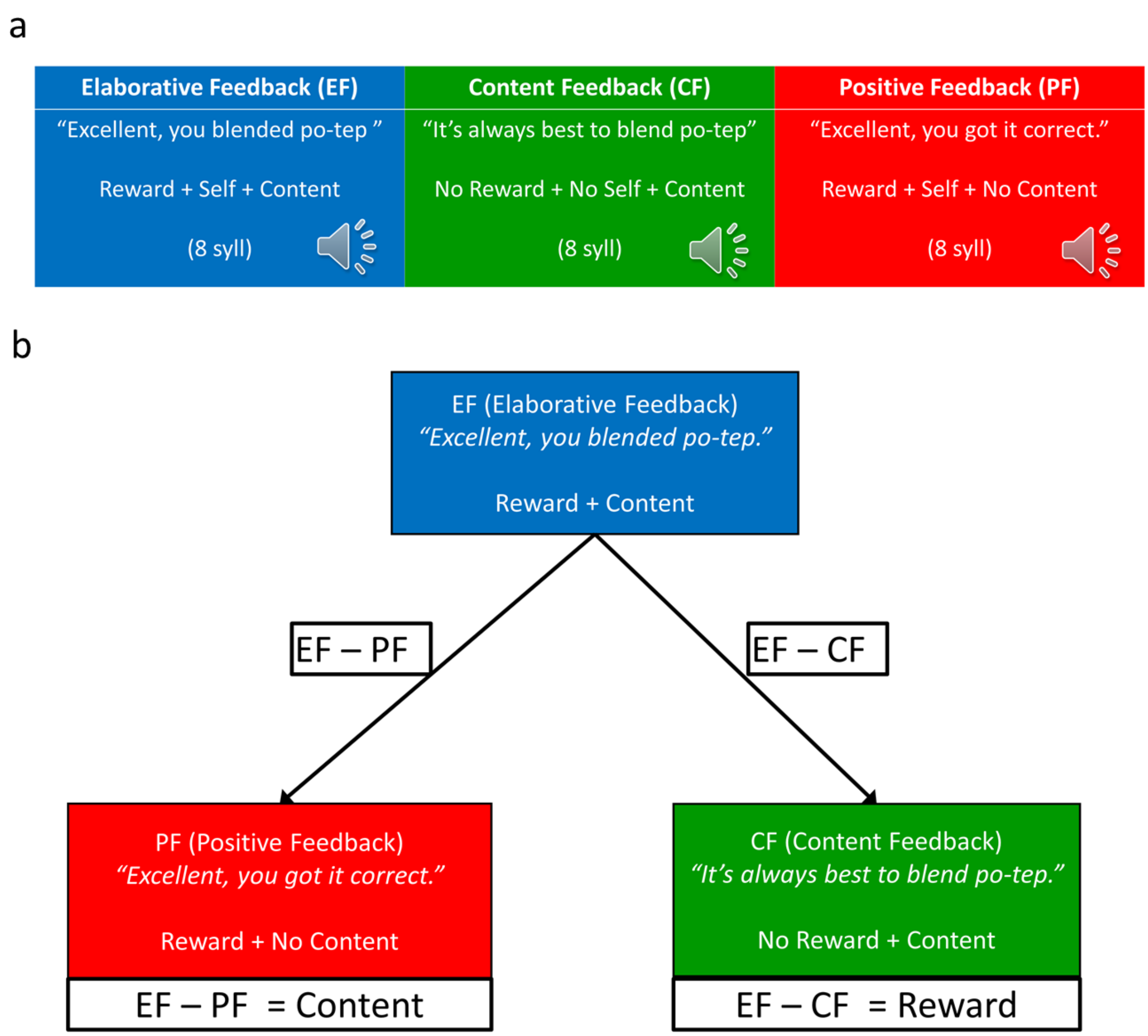


Figure 1a: The three types of feedback are displayed. Each type was matched on number of syllables, duration (s), pitch (Hz), and intensity (dB). b: Planned contrasts between the

three feedback types.

1.3.3 Procedure

There were three phases in the study, all of which were conducted during scanning. During the first phase, the Learning Phase, each pseudoword appeared once on the screen, in random order, for one second. Participants were asked to read the pseudoword aloud while speaking clearly into the Advanced Noise Cancelling Fiber Optic Microphone for fMRI. After the pseudoword was read aloud, the correct pronunciation was played through the speakers. The participant was instructed to listen carefully to the pronunciation of each pseudoword.

In the second, Feedback Phase, each pseudoword appeared on the screen, and the participant was asked to read it aloud into the microphone (Figure 2a). The experimenter sat in the control room and pressed a “y” or “n” for correct or incorrect answers, in order for participants to receive appropriate feedback based on their response. Participants saw an “X” after an incorrect response. After a correct response, participants received one of the three types of feedback as described above. Each word appeared six times successively, regardless of whether or not the answer was correct.

In the EF and CF conditions, the hyphenated pseudoword was presented visually on the screen starting at two seconds from the start of the auditory feedback (e.g. “You blended po-tep”). Visual presentation of the pseudoword lasted two seconds and ended simultaneously with the completion of the auditory feedback (Figure 2a). The experiment was presented using PsychoPy (Peirce, 2007), a standardized, open-source software platform for conducting computerized psychology experiments.

During the last, or Testing Phase, each pseudoword appeared once on the screen in randomized order, and the participant was asked to read it aloud (Figure 2b). During each of the three phases, a fixation cross appeared on the screen between trials with randomized inter-stimulus intervals following a fully event-related design.

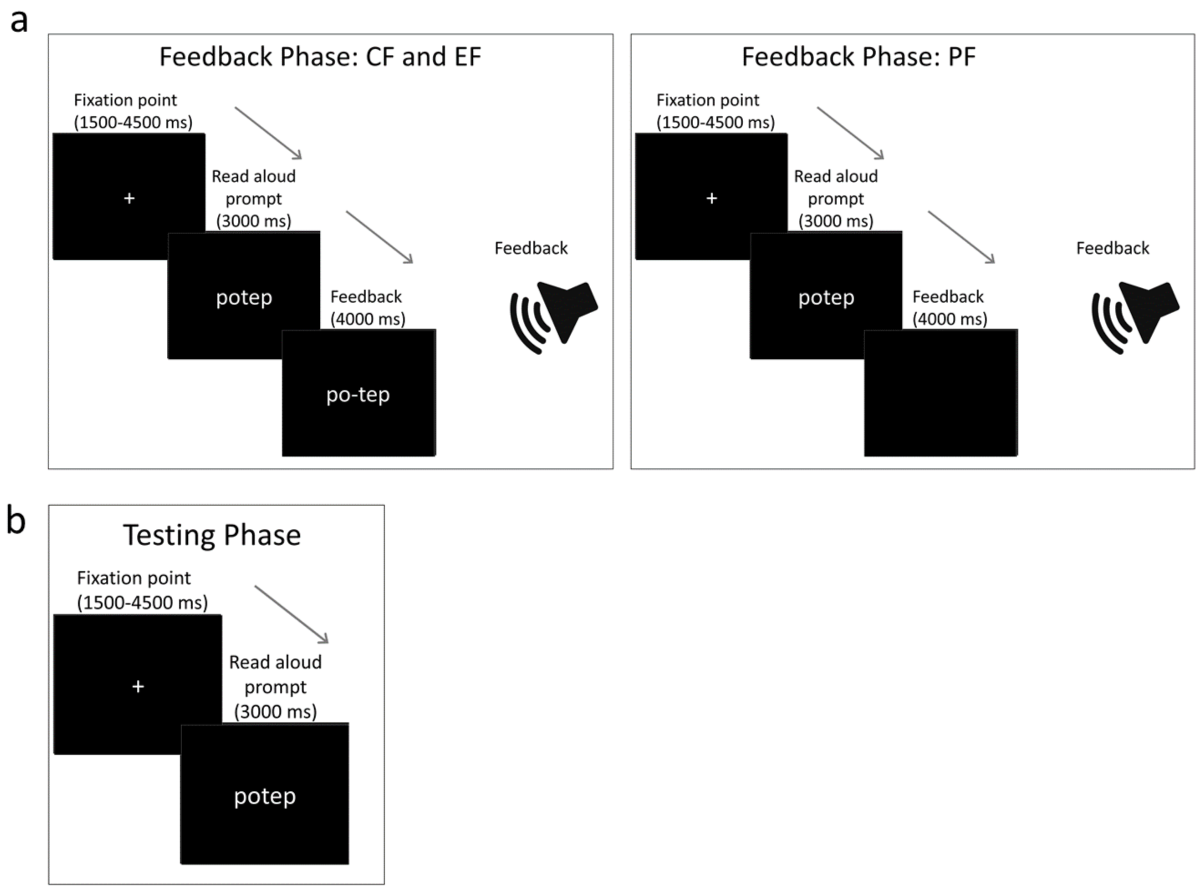


Figure 2a: Feedback phase for Content Feedback (CF) and Elaborative Feedback (EF), where audio feedback was paired with visual presentation of the hyphenated pseudoword; Feedback phase for Positive Feedback (PF), where audio feedback was paired with no visual presentation of the pseudoword. The duration of each stimulus presentation is shown in milliseconds (ms). b: Testing Phase, where pseudowords were presented on the screen and participants asked to read each pseudoword aloud.

To familiarize participants with the procedure prior to the start of the study, participants also engaged in a practice run, which included a shortened version of each of the three study phases.

1.3.4 Post-scan Measures

To facilitate comparison of measured performance for each feedback type with participants' subjective experience, participants were given an eight item Likert scale questionnaire after the experiment (Appendix C). The scale ranged from 1 to 5, assessing their ratings of pleasantness and helpfulness of each type of feedback, and self-rating their level of reading difficulty as a child and as an adult. An example of an item assessing the helpfulness of a feedback type is: "To what degree was the following feedback helpful: 'It's best to blend – ---'," with responses ranging from 1- Not helpful at all, to 5- Very helpful. An example of an item assessing the pleasantness of a feedback type is: "To what degree was the following feedback pleasant: 'It's best to blend – ---'," with responses ranging from 1- Very unpleasant, to 5- Very pleasant. Level of reading difficulty as a child and adult were assessed with two separate questions: "To what degree did you experience difficulty reading, as a child (or adult), in learning to read?" Responses ranged from 1- No difficulty at all to 5- Severe difficulty.

1.3.5 Data analysis

Response times (RT) for participants' spoken responses during the Testing Phase were calculated as the duration from the onset of the visual pseudoword display to the onset of participant speech. A rater who was blinded to feedback type analyzed each pseudoword response for timing by listening to and viewing the waveform of the audio file corresponding to each pseudoword response. Accuracy during Feedback and Testing Phases was also recorded. If both the first and second syllable of the pseudoword were pronounced correctly, including correct pronunciation of the vowel sound (short or long), the pronunciation was marked as correct and received a score of 1. If either or both of the syllables were read incorrectly, the item received a score of 0, signifying incorrect. Accuracy was scored by independent raters who were blind to the feedback type with which each pseudoword was trained. A subset of items from the Testing Phase (n=72) were scored by both raters to ensure inter-rater reliability, yielding a Cohen's Kappa (Cohen, 1960) of 0.65, a value established by previous studies to be in the acceptable range (Landis & Koch, 1977). Accuracy during the Feedback Phase was recorded by PsychoPy based on the experimenter's keypress ("y" or "n") after listening to the participant's response.

On two out of 228 total trials (0.9% of trials), the experimenter mistakenly coded accurate participant responses as being inaccurate. The experimenter informed the participant immediately that an experimenter error was made. This occurred during the feedback phase of the experiment. In the behavioral analysis of Testing Phase accuracy and reaction time (RT), the data for these two pseudowords were simply excluded from the analysis. For the neuroimaging analysis (discussed further below), the feedback trials for these two pseudowords were coded separately in the regression analysis as errors, and thus were not included in the feedback condition regressors.

To examine the effectiveness of the different feedback types, a one-way Analysis of Covariance (ANCOVA) was performed, using accuracy during the Testing Phase as the dependent variable, accuracy during the Feedback Phase as a covariate, and Feedback Category as the independent variable of interest with three levels (EF, CF, and PF). Testing accuracy was calculated by averaging each participant's accuracy for reading aloud the four pseudowords in each feedback condition. Feedback accuracy was calculated by averaging each participant's accuracy for each of the six repetitions of the four pseudowords during the Feedback Phase. Accuracy during the Feedback Phase was included as a covariate because feedback was given only for correct answers during this phase, such that the number of correct responses determined the number of times the feedback was received. If, for example, an individual was not successful at pronouncing the pseudoword correctly during the Feedback Phase, he or she would not have heard the feedback specified for the given target pseudoword. This, in turn, would presumably affect the influence of feedback on performance during the Testing Phase.

An additional mixed effects linear regression model was used to determine the contrast coefficients for each feedback condition, adjusted for the covariate (accuracy during the Feedback Phase) and for random subject-level variance, following the general approach outlined by Baayen and colleagues (2008). In this model, EF and CF were entered as regressors, with PF serving as an implicit baseline for comparison with the other two conditions. As such, the resulting coefficient for EF represents the effect of EF compared to PF; and the coefficient for CF represents the effect of CF compared to PF. This resulted in coefficients representing the effect of each feedback type on Testing Phase accuracy, adjusted for feedback phase accuracy and for random subject variance.

1.3.6 fMRI data acquisition and analysis

Magnetic resonance imaging data were collected on a 3-T Siemens Magnetom TrioTim Scanner with a 12 channel head coil. A T1 high-resolution anatomical brain scan was collected for each participant, using a 3-dimensional magnetization-prepared rapid gradient-echo (MPRAGE) sequence, with a TR of 1900 milliseconds (ms) and a TE of 2.52 ms (matrix = 256 x 256 voxels, 176 contiguous 1 mm axial slices, field of view, FOV = 256 mm, flip angle = 9 degrees). Four runs of Blood Oxygen Level Dependent (BOLD) data were collected using a gradient-echo echoplanar imaging (EPI) sequence (TR = 2000 ms, TE = 25 ms, FOV = 208 mm, matrix = 64 x 64, flip angle = 60 degrees). Each volume consisted of 35 axial slices (3.25 x 3.25 x 3 mm voxels).

All images were preprocessed using the AFNI software suite (http://afni.nimh.nih.gov/afni; Cox, 1996). For each participant, the first 6 images in each run were ignored due to initial saturation. Slice timing and motion correction were applied to the time series images, and the high-resolution structural scan was then aligned to these images (Saad et al., 2009). Additional noise covariates from motion correction parameters and signal in the ventricles were entered as regressors of no interest. Regressors of interest were included for each feedback condition paired with pseudoword presentation for each feedback type, during the Feedback Phase, and analyzed using the AFNI program for statistical regression, 3dDeconvolve. Pseudoword stimuli were paired with trial number using the amplitude modulated option in 3dDeconvolve, in order to analyze modulation of neural activity by trial number (presentations 1-6). Only correct trials were included in the main analysis. Trials with erroneous responses (e.g., mispronounced pseudoword) were modeled separately. Each subject's anatomical scan was aligned to the Talairach atlas (Talairach & Tournoux, 1988), and this alignment solution was applied to align each subject's image regression results to the same atlas. The group analysis was subsequently conducted on these registered images for each condition. A brain mask excluding most white matter and cerebrospinal fluid was applied to all contrast images, as well as a smoothing kernel of 6 mm FWHM. A two-tailed t-test with a voxelwise threshold of $p < 0.005$, and a cluster correction of 617 μl (mapwise corrected $p < .05$) was used. Note that this voxelwise threshold is more strict than the $p < 0.01$ threshold identified by Eklund, Nicols, & Knutsson (2016) as being problematic for controlling false positives in fMRI. The AFNI program 3dttest++ was used to obtain group contrast images. Each individual's WTAR score was entered as a covariate in order to account for any effects of differences in VIQ. An additional analysis examined the correlation between accuracy during the testing round for each particular feedback type, and neural activation during pseudoword presentation as well as receipt of feedback.

1.4 Results

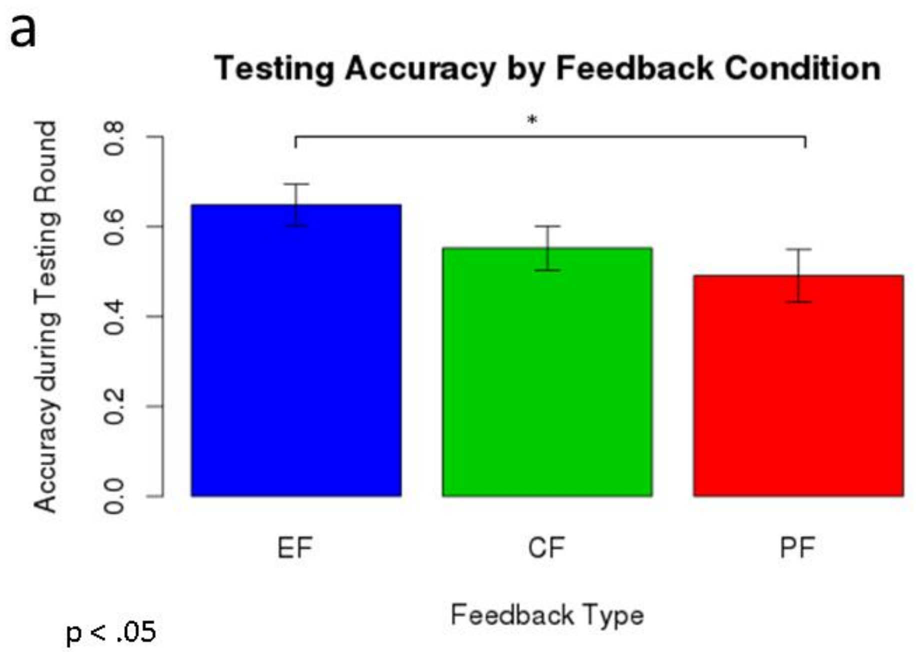
1.4.1 Behavioral Results

Performance was analyzed in terms of RT and accuracy. During the Testing Phase, analysis of RT showed that pseudowords did not reliably differ by feedback training condition (rightmost column of Table 2). In terms of accuracy during the Testing Phase, there was a significant main effect of feedback type, $F(1,15) = 3.77$, $p < 0.05$. Pseudowords trained with Elaborative Feedback (EF; e.g. "Excellent, you blended po-tep") were read aloud during the Testing Phase with higher accuracy than those trained with Content Feedback (CF; e.g. "It's best to blend po-tep") and Positive Feedback (PF;

“Excellent, you got it correct”), as shown in the “Testing Acc” column of Table 2 and Figure 3a. Pairwise comparisons revealed a significant difference in testing accuracy (unadjusted for accuracy during the Feedback Phase) between EF and PF, $t(18) = 2.19$, $p < 0.05$; but no significant difference between EF and CF, $t(18) = 1.24$, $p > 0.05$. The linear regression model provided an estimate of the effect size of EF and CF relative to PF, after taking into account Feedback Accuracy. This model showed an increase of 0.18 points, or about an 18% increase, in accuracy (p < 0.01) for EF, and an increase of 0.12 points ($p > 0.05$), or a 12% increase in accuracy for CF, in comparison to reference variable, PF. As expected, accuracy during the Feedback Phase, during which the participant was actively learning the pseudoword pronunciations, did not differ by condition: $F(1,15) = 2.41$, $p > 0.05$ (“Feedback Acc” column of Table 2). Accordingly, pairwise comparisons revealed no significant difference between EF and CF on Feedback Accuracy, $t(34) = 1.094$, $p > 0.05$; EF and PF, $t(34) = -0.667$, $p > 0.05$; or EF and PF, $t(34) = -1.73$, $p > 0.05$.

	Feedback Acc	**Testing Acc**	**Testing RT**
EF	.86 (.12)	.65 (.20)	1.33 (.85)
CF	.81 (.15)	.55 (.21)	1.33 (.76)
PF	.88 (.11)	.49 (.25)	1.25 (.69)

Table 2: Mean accuracy during the Feedback phase (Feedback Acc), accuracy during the Testing phase (Testing Acc), and response time during the Testing Phase (Testing RT) for each condition. Standard deviations are in parentheses.



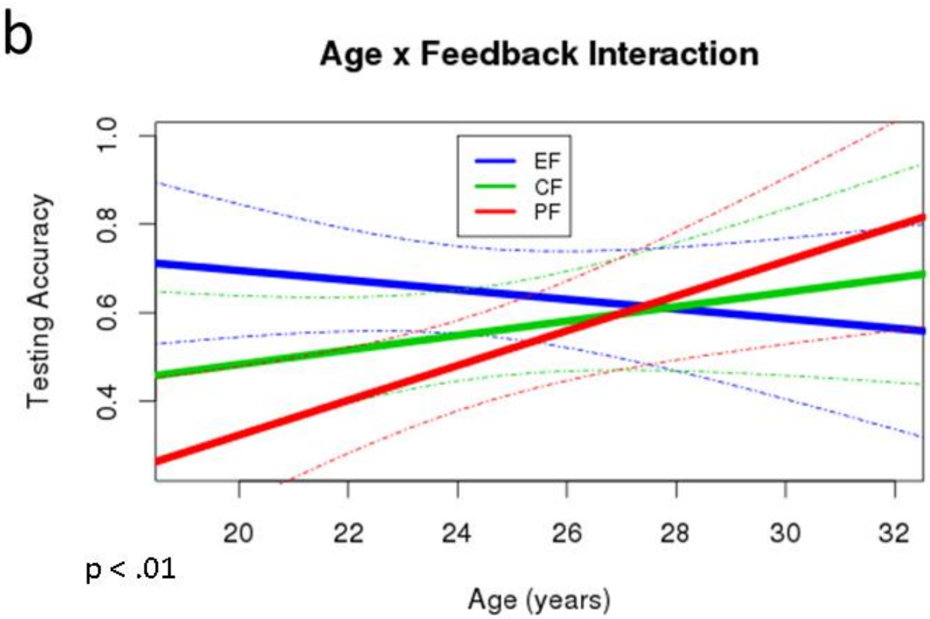


Figure 3a: Elaborative Feedback (EF) resulted in the highest accuracy, compared to Positive Feedback (PF) and to Content Feedback (CF); ANCOVA: $p < 0.05$. b: Interaction of age and feedback condition (Elaborative Feedback, EF; Content

Feedback, CF; Positive Feedback, PF). Younger participants showed a stronger effect of feedback condition. Dotted lines represent 95 percentile confidence intervals.

Because 4 of the final 19 participants were bilingual or multilingual, we tested for any influence of number of languages spoken on task performance. An ANCOVA analysis, with Testing Accuracy as the dependent variable, Feedback Accuracy as the covariate, and the interaction of feedback condition with languages spoken (bilingual or multilingual vs. monolingual), revealed no main effects of languages spoken on accuracy, $F(1,16) = 0.55$, $p > 0.05$, nor any interaction effects of languages spoken with feedback condition, $F(1,16) = 0.61$, $p > 0.05$.

Self-report ratings of reading difficulty experienced as a child and as an adult were collected to ensure that effects of feedback were stable across reading levels, and to verify that there were no major differences according to self-reported reading levels. An ANCOVA analysis revealed no main effect of self-reported reading difficulty as a child, $F(1,16) = 0.347$, $p > 0.05$, or as an adult, $F(1,16) = 0.127$, $p > 0.05$, and no significant interaction between feedback condition and reading difficulty as a child, $F(1,16) = 0.339$, $p > 0.05$, or adult, $F(1,16) = 0.436$, $p > 0.05$.

We also performed an exploratory analysis to determine if there is any initial evidence of greater benefit for EF relative to the other feedback types for participants of decreasing age. To maximize power within the limited age range or our participants, age was treated as a continuous variable. Using an ANCOVA analysis on accuracy data in the Testing Phase, we tested for the multiplicative interaction of feedback conditions with age. This revealed a reliable interaction, with a greater effect of feedback condition for younger participants, $F(1,16) = 6.53$, $p < 0.01$ (Figure 3b). This interaction held even when the effects of VIQ and the interaction of VIQ and feedback condition were entered into the model, $F(1,15)=6.35$, $p < 0.01$.

To determine whether or not the most effective types of feedback were also experienced as the most pleasant, we performed additional post-hoc analyses of subjective ratings provided by participants. Positive Feedback was rated as the most pleasant type of feedback on a scale from 1 to 5, with 1 being: "Very unpleasant," and 5 being "Very pleasant." EF was rated the second most pleasant (EF: $M = 4.42$, SD = 0.69; CF: $M = 3.42$, SD = 1.12; PF: $M = 4.63$, SD = 0.59), $F(1,18) = 26.56$, $p < 0.001$ (Figure 4a). EF and PF were rated as equally pleasant. When considered together with the fact that EF resulted in higher accuracy than PF, this pattern suggests that the effectiveness of EF may be due to pairing of skill-content and reward information. Finally, congruent with effectiveness of feedback, EF was rated as the most helpful on a scale from 1 to 5 (EF: 4.26, SD = 0.93; CF: 3.47, SD = 1.12; PF: 4.11, SD = 0.99), $F(1,18) = 3.97$, $p < 0.05$ (see Figure 4b).

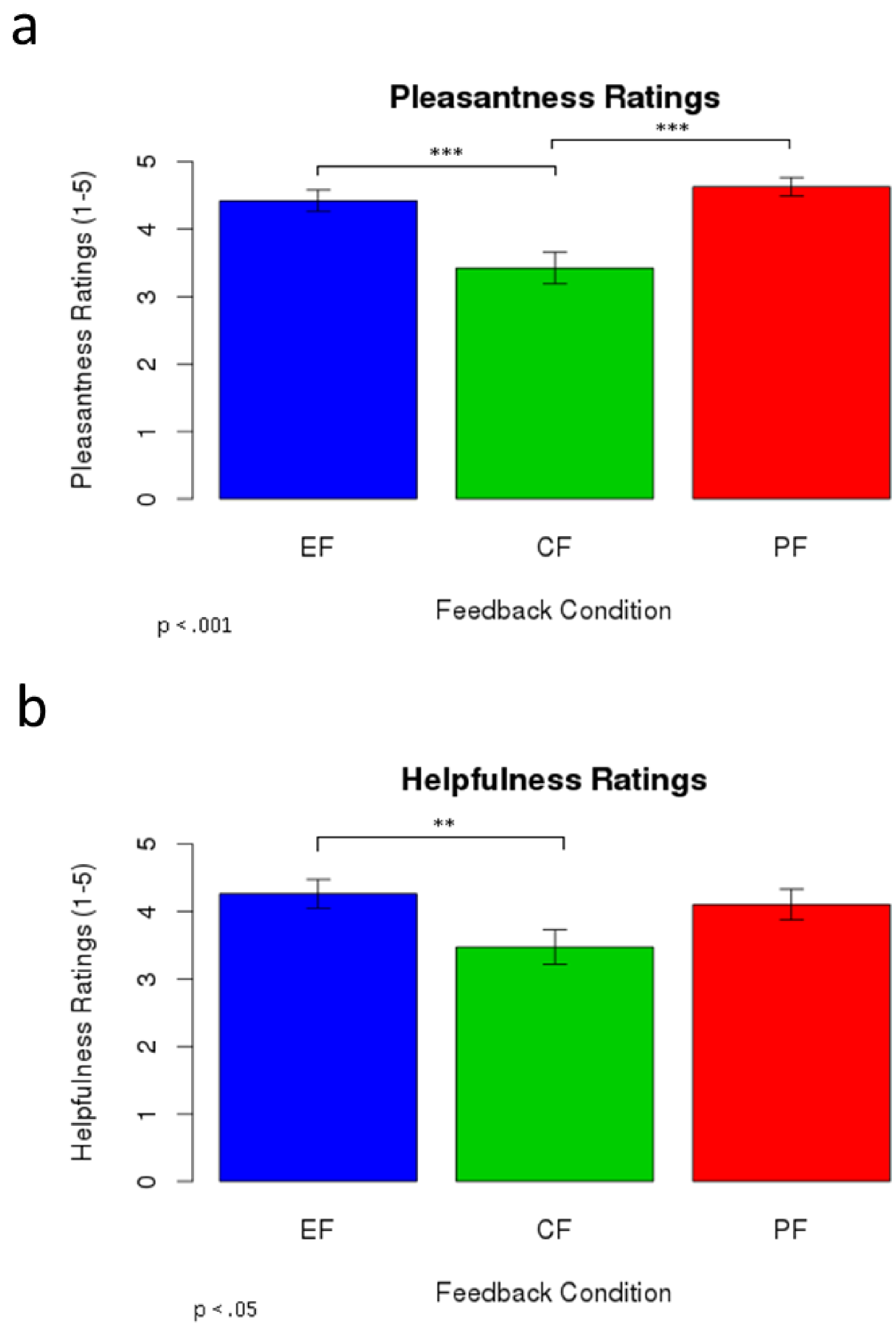


Figure 4a: Positive Feedback (PF) and Elaborative Feedback (EF) were rated as more pleasant than Content Feedback (CF). b: EF was rated as more helpful than CF.

1.4.2 Neuroimaging Results: Comparisons by feedback type

Analyses of neural activation by feedback type during the feedback phase yielded results that were generally in line with our hypotheses. Directly contrasting Elaborative and Content Feedback, Elaborative Feedback significantly activated the vmPFC (Figure 5a), while Content Feedback activated a large portion of the bilateral frontal cortex including the bilateral dlPFC and IFG, as well as the bilateral AG and MTG (Figure 5a). Directly contrasting Elaborative and Positive Feedback, Elaborative Feedback activated the left vOT/FG, left pSTG extending to pMTG, and SMG (Figure 5b), while Positive Feedback activated the posterior cingulate cortex (pCing, Figure 5b). Directly contrasting Content and Positive Feedback, Content Feedback activated the bilateral vOT/FG, left pSTG, SMG, and IFG, while Positive Feedback activated the vmPFC (Figure 5c).

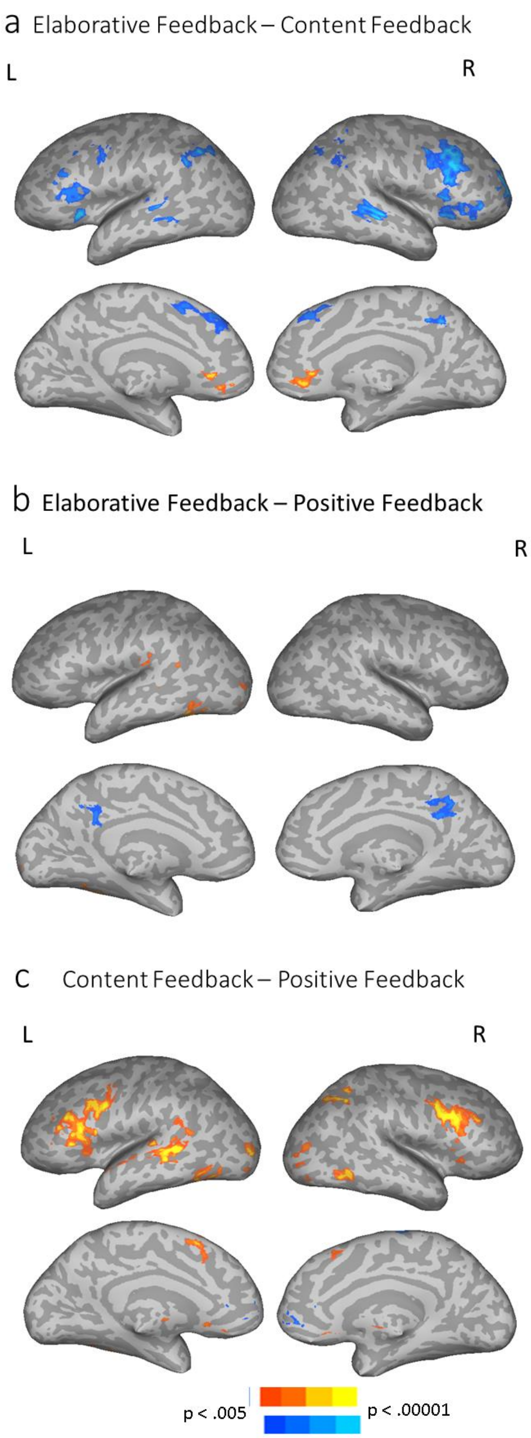


Figure 5a: Contrasting Elaborative Feedback (EF) with Content Feedback (CF), EF (warm colors) activated the vmPFC. CF (cool colors) bilaterally activated the dlPFC, IFG, AG, and MTG. b: Contrasting EF with Positive Feedback (PF), EF (warm colors)

activated the left SMG, pSTG extending to pMTG, and vOT/FG. PF (cool colors) activated the precuneus/pCing. c: Contrasting CF with PF, CF (warm colors) activated the left STG, SMG, and bilateral IFG and vOT/FG. PF (cool colors) activated the vmPFC.

Considering that the vmPFC is in an area sensitive to fMRI signal drop-out, the mean signal in the vmPFC ROI (the resulting cluster of the EF > CF contrast) was plotted against the beta values for each participant's EF – CF contrast. No significant correlation was found between the mean signal and beta value for EF – CF, r(19) = -0.14, $p > 0.05$, thus verifying that the effect was not driven by low signal levels in this region.

Distinct from the feedback phase just described, this study was not designed to test neural activation during the Testing Phase, given the small number of words per condition in that phase. Accordingly, no activation differences were found among feedback conditions during this phase.

1.4.3 Neuroimaging results: Pseudoword comparisons

The fact that the feedback directly followed pseudoword presentation allowed us to examine how the BOLD signal during pseudoword presentation was modulated by feedback type. We also included trial number as a covariate to see how neural activation over the course of the six learning trials may have differentially changed by feedback type. Note that it is this whole-brain analysis that established the location of significant interaction effects. Follow-up analyses to describe the pattern of the interactions were then performed. Activation in the left IFG was modulated by trial number differently for EF compared to CF (Figure 6a) and for EF compared to PF (Figure 6b). Since the resulting clusters in the EF – CF and EF - PF analyses covered both the IFG and STG, these regions were plotted separately to visualize the activation pattern in each region. Two ROIs were generated with a radius of 3 mm surrounding a maximum point in the IFG (x = -50, y = 17, z = 2) and a maximum point in the STG (x = -45, y = -5, z = 1). Parameter estimates were plotted for each trial for both the STG and IFG separately for EF vs. CF. Since the overall pattern was the same for pseudowords in these two ROIs, and the cluster covered a greater portion of the IFG, only the IFG plot is shown. To better characterize the interaction effect, a linear regression was conducted on the parameter estimates for the IFG sphere, with trial number as the independent variable. This analysis showed no effect of trial number on IFG activation for pseudowords trained with EF, $F(1, 18) = -1.69$, $\beta = -0.23$, $p > 0.05$, but a significant positive effect of trial number on IFG activation for pseudowords trained in the CF condition, $F(1,18) = 5.39$, $\beta = 0.77$, $p < 0.0001$.

Similarly, in the EF vs. PF contrast, one ROI was generated in the left IFG at the local maximum (x = -44, y = 2, z = 11) and another in the left STG (x = -56, y = -4, z = 2). Parameter estimates were plotted separately, and again, the overall pattern was the same for both the left IFG and left STG. Only the IFG parameter estimates are shown in Figure 6b. A linear regression on the parameter estimates for the IFG ROI revealed no effect of trial number for EF, $F(1,18) = -0.36$, $\beta = -0.04$, $p > 0.05$, but a significant main effect of trial number on IFG activation for pseudowords trained in the PF condition, $F(1,18) = -4.208$, $\beta = 0.33$, $p < 0.01$.

Trial number during the feedback phase also modulated activity in the caudate differently for EF compared to CF (see Figure 6a) and PF (see Figure 6b). Since the cluster included a small portion of the cingulate as well, a 3 mm sphere surrounding the maximum points in the caudate for both the EF – CF contrast (x = -13, y = 15, z = 15) and the EF – PF contrast (x = -13, y = 7, z = 20) were created. Again, the pattern was the same in the caudate as in the overall cluster, but only the parameter estimates for the caudate were plotted so as to exclude activation in surrounding brain regions. The overall pattern in both the left and right caudate was similar as well for both the EF – CF and EF – PF contrasts; only the left caudate plots are shown in Figure 6b. To better characterize the modulation by trial number in the EF – CF and EF – PF contrasts, we conducted a linear regression on the caudate parameter estimates for each condition. For EF compared to CF, trial number significantly negatively predicted neural activation in the caudate ROI, $F(1,18) = -5.92$, $\beta = -0.55$, $p < 0.0001$; but there was no significant effect of trial number for CF, $F(1,18) = -.47$, $\beta = -0.05$, $p > 0.05$. In the EF – PF contrast, trial number significantly negatively predicted neural activation in the caudate ROI, $F(1,18) = -4.2$, $\beta = -0.55$, $p < 0.0001$; but there was no effect of trial number for PF, $F(1,18) = -0.16$, $\beta = -0.02$, $p > 0.05$.

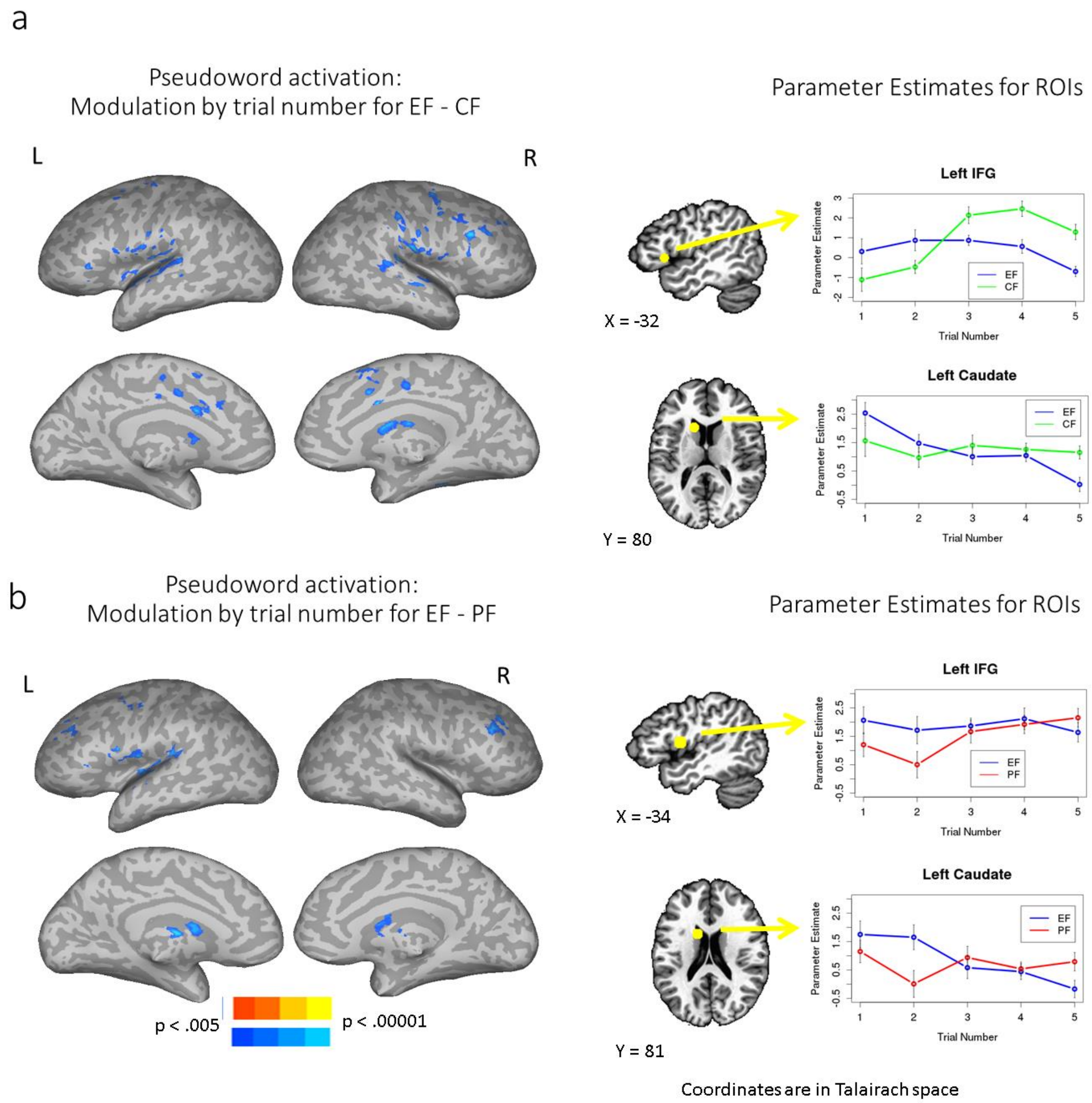


Figure 6a: Left: Interaction of EF – CF pseudoword presentation during the Feedback Phase with modulation by trial number. Right: Graphs represent parameter estimates for each trial number for an ROI in the left IFG sphere (shown on the sagittal slice, X = -32) and left caudate sphere (shown on the axial slice, Y = 80). b: Left: Interaction of EF - PF pseudoword presentation during the Feedback Phase with modulation by trial number. Right: Graphs represent parameter estimates for the ROI in the left IFG sphere (shown on the sagittal slice, X = -34) and left caudate sphere (shown on the axial slice, Y = 81). Coordinates are in Talairach space.

1.5 Discussion

1.5.1 Interpretation of behavioral results

Feedback that praises the learner for correctly applying the target skill (EF) was predicted to be more helpful than that which only praises the learner (PF) or only provides skill-content information (CF). In line with these predictions, participants learned to pronounce novel letter strings with higher accuracy when the pseudowords were trained with Elaborative, than with Positive or Content Feedback, suggesting that Elaborative Feedback promotes learning the orthography-phonology conversion for novel letter strings. This is consistent with previous literature demonstrating feedback to be most effective when it provides specific information about the use of strategies (Brinko, 1993) and more elaborative compared to simple information (Lin et al., 2013). The novel contribution, however, is that this study provides specific evidence for the use of Elaborative Feedback to support an essential literacy skill—orthography to phonology conversion. Given that difficulties in orthography-phonology conversion typically underlie reading difficulties (Blomert, 2011; McNorgan, Randazzo-Wagner, & Booth, 2013), improving upon this skill is of high importance for struggling readers. While systematic instruction in orthography-phonology conversion has previously been shown to be effective (Ehri et al., 2001), our study has demonstrated an additional advantage through the use of a particular kind of feedback that explicitly combines information about orthography-phonology mappings with positive verbal reinforcement for correct answers.

The post-hoc analysis examining the interaction of age with feedback condition shows that in our sample, younger individuals benefited more from EF, which included both reward and explicit skill content, compared to feedback that simply indicated that their answer was correct (PF). This is consistent with previous research showing that adolescents may be more sensitive than adults to positive social feedback (Cauffman et al., 2010; Jones et al., 2014) and less able to learn from negative feedback (Cauffman et al., 2010). Although in those two studies, adolescents up to age 17 were compared to adults aged 18-25, recent research demonstrates that during emerging adulthood, 18 to 25, cognitive and affective patterns may resemble those of adolescence (Arnett & Jensen, 2000). This is relevant to the current study, where participants ranged from 19 to 32 years old, offering evidence that responsiveness to feedback type may also differ between periods of emerging and later adulthood. While we take caution in interpreting these results due to the limited age range of the participants, we do suggest that our results are promising enough to warrant further testing of positive, specific feedback for younger individuals.

The analysis of subjective ratings suggests that feedback in the form of praise elicits positive affect and a sense of efficacy, yet may not be effective in promoting learning without additional informational (skill) content. EF was rated as more pleasant and helpful than CF, and resulted in the highest mean accuracy score. These results suggest that by combining praise with skill content, EF elicits reward value associated with the target skill, thus improving learning. If future studies demonstrated that these results generalized to struggling readers, this would be particularly important for these individuals, whose adverse affective reactions to their difficulties may further deter their progress (Dweck, 1975; Dweck & Bempechat, 1983). Feedback that is both rewarding and informative may counter these negative affective reactions, thereby potentially improving learning for struggling readers.

1.5.2 Interpretation of neuroimaging results: Feedback processing

As predicted, EF recruited neural regions implicated in both reward and orthography-phonology content. Compared to CF, EF recruited the vmPFC, implicated in both reward (Blair et al., 2006; for review, Smith & Delgado, 2015) and self-processing (D'Argembeau, 2013). Given that EF was rated as more rewarding than CF, activation of this region for EF compared to CF is likely due to reward processing. The vmPFC has been implicated in encoding reward value, including expected monetary outcomes (Knutson et al., 2003) and social rewards (Somerville et al., 2010). In one study, participants with low self-esteem showed increased activity in this region for positive compared to negative social feedback (Somerville et al., 2010), suggesting a role for the vmPFC in evaluating the salience of a social reward. Since in EF the learner's actions are being perceived by another, it may be that the vmPFC is recruited due to this social aspect. However, interpretation of the results of the EF-CF contrast is limited due to the presence of two differences between the EF and CF conditions. EF involves both reward and self-processing, as compared to CF, which involves only task-relevant information. Thus, activation of the vmPFC for EF compared to CF cannot be attributed specifically to reward or self-processing. However, research suggests that activation of vmPFC for self-processing may be due to assigning personal value for self-related concepts (D'Argembeau, 2013). For example, this region was recruited for processing evaluative feedback (e.g., "You're a great girl!"; Pan, Hu, Li, & Li, 2009). Therefore, even if activation of vmPFC was due to self-processing in the EF compared to CF condition, it is likely that such recruitment is also reward-related.

On the flip side of the same contrast, CF showed greater activation than EF in a number of regions previously shown to be involved in reading, such as the MTG, IFG, and AG (Binder, Medler, Desai, Conant, & Liebenthal, 2005; Fiez, Balota, Raichle, & Petersen, 1999; Graves et al., 2010; Turkeltaub, Eden, Jones, & Zeffiro, 2002), as well as the dlPFC (Barbey, Koenigs, & Grafman, 2013; Owen, McMillan, Laird, & Bullmore, 2005), implicated in working memory. It is somewhat surprising that CF resulted in greater activation of reading network regions, compared to EF, given that skill-content was equated across these two conditions. Such activation may be due to greater attention to the skill-content in CF, when an individual is told what skill should be applied in order to achieve the correct answer. Interestingly, although CF recruited reading network regions to a greater degree than EF, EF resulted in higher accuracy. Thus, it is likely that pairing reward and skill-content is responsible for the effectiveness of EF. Further, activation of the dlPFC for CF is consistent with research showing activation of this region for negative feedback (Zanolie et al., 2008; Kiki Zanolie et al., 2008), especially when feedback is informative for achieving a correct answer on the subsequent trial (Zanolie et al., 2008). Although CF was provided on correct and not incorrect trials, its form was similar to negative feedback, in that it provided the learner with information regarding the skill which should be applied in order to achieve the correct answer. Thus, dlPFC activation for CF is consistent with this literature.

Consistent with our predictions, EF compared to PF recruited regions involved in orthography-phonology processing including the fusiform gyrus, MTG, SMG, and STG.

While previous studies have shown recruitment of these regions for engaging in orthography-phonology tasks (Binder et al., 2005; Fiez et al., 1999; Graves et al., 2010; Turkeltaub et al., 2002), this is the first study to our knowledge that has demonstrated such activation during the receipt of feedback.

The opposite contrast, PF compared to EF, resulted in activation of the pCing, a region considered part of the putative default-mode network. This is a set of mutually correlated regions typically found to be active during conditions in which participants are not engaged in any particular task (Buckner, Andrews-Hanna, & Schacter, 2008; Gusnard, Raichle, & Raichle, 2001). Given that Positive Feedback also resulted in lower accuracy than Elaborative Feedback, the pCing activation may correspond to the learners being less engaged in the task during the receipt of Positive compared to Elaborative Feedback.

Lastly, PF was also compared to CF, with the prediction that PF would recruit reward-related regions, and CF would recruit task-related regions. These predictions were also supported. PF recruited the vmPFC, while CF recruited the left MTG, STG, SMG, and vOT/FG. This provides additional confirmation that PF recruited reward- but not task-related regions, and CF recruited task- but not reward-related regions, thus validating the results of the EF - PF and EF - CF contrasts.

1.5.3 Interpretation of neuroimaging results: Pseudowords

Higher accuracy for pseudowords trained with Elaborative Feedback, along with a relative lack of activation increase in reading-related neural regions while reading aloud these pseudowords as trial number increased, suggests greater habituation to pseudowords trained with Elaborative Feedback. Previous literature has found similar habituation effects for trained items. For example, Graves et al. (2008) found decreased neural activity in the left pSTG over the course of six trials on which participants repeated auditory pseudowords. In our study, the fact that activation in the left IFG and STG remained steady for pseudowords trained in the Elaborative Feedback condition, but increased for the other feedback conditions, combined with the greater accuracy for Elaborative Feedback than the other conditions, suggests that these areas may be maintaining information for accurately pronouncing pseudowords. Another possibility is that activation in these areas may reflect increased recruitment of resources in the service of learning to pronounce pseudowords under conditions of less beneficial feedback. This interpretation is consistent with literature finding increased activation of some reading-related regions, including the IFG, under conditions that were more difficult, due to either word characteristics (Graves et al., 2017, 2010) or domain-general demands (Fox & Raichle, 2007; Fox et al., 2005).

Modulation of the caudate by trial number for Elaborative, but not Positive or Content Feedback, supports the role of the caudate in feedback processing. However, interestingly, Elaborative and Positive were both rated as more pleasant than Content Feedback, yet the caudate was modulated by trial number only for Elaborative and not Positive Feedback, suggesting that recruitment of the caudate for Elaborative Feedback may be due to the coupling of rewarding and skill content. Specifically, the caudate has previously been shown to facilitate action – outcome associations (Knutson & Cooper, 2005), and here may have facilitated the binding of reward and reading-related information, thereby leading to higher accuracy in this condition.

Together, behavioral and neuroimaging main results suggest the enhanced effectiveness of EF may be due to concurrent activation of reward-related and reading-relevant regions. Thus, receiving elaborative feedback upon correctly applying a skill may not only promote learning, but may also enhance the reward value of a target skill.

1.5.4 Limitations

While this study provides evidence of the effectiveness of EF in an orthography-phonology learning task, the question of generalizability of results from adults to children and adolescents remains. The current study has provided proof of concept in the form of evidence that the feedback manipulation is effective among adults. Follow up analyses also showed Elaborative Feedback to be particularly effective in this sample for the younger end (18-23 years) of our adult age range. This suggests it may at least be worth exploring the usefulness of Elaborative Feedback with younger developing readers in future studies.

Additionally, since the Content Feedback condition provided instructive feedback on spelling-sound content, its status as reinforcing a skill they had just demonstrated may have been a bit ambiguous. Mitigating this concern, however, is the fact that participants did change their answers on subsequent trials when an “X” was provided to indicate it was incorrect, but repeated their answers when Content Feedback was provided, demonstrating that they at least understood that Content Feedback indicated that their answer was correct.

Regarding the stimuli, although average pitch was matched across feedback types, it is possible that feedback types differed in natural pitch fluctuations due to differences in social and emotional content. We chose not to control pitch fluctuations, as this may have diminished the natural social and emotional cues present in the feedback. While potential differences in pitch fluctuations across feedback types may be a confound in the study, we feel our results are unlikely to be due to differences in basic auditory characteristics of the feedback. Instead, pitch fluctuations have been shown to modulate neural regions in the auditory cortex, while our results demonstrate activation in areas outside this region, including the supramarginal and fusiform gyri. Moreover, if activation in the temporal cortex, for example, were due to pitch intonation differences, one would expect similarity between Elaborative and Positive Feedback, which were more similar in emotional content (participants rated these two types of feedback as more rewarding than Content Feedback). On the contrary, activation in auditory cortex was greater for Elaborative than Positive Feedback and greater for Content than Positive Feedback. Since Elaborative and Content Feedback differed in reward ratings, but included the same content (orthography-phonology mapping), the resulting activation in the auditory cortex is likely due to the skill content (present in both Elaborative and Content Feedback) rather than reward ratings (different for Elaborative and Content Feedback).

Lastly, both Content and Elaborative, but not Positive Feedback, presented the target pseudoword both visually and auditorily. This was done in order to highlight neural regions implicated in orthography (visual pseudoword presentation) and phonology (auditory pseudoword presentation). The contrast of neural activation during the receipt of feedback for EF - PF and CF - PF were designed such that EF and CF included skill content (pseudoword visual and auditory presentation), but PF did not, and thus was used as a baseline comparison for skill content in these contrasts. However, a limitation remains in that neural activation for EF vs. PF and CF vs. PF could be due to mere exposure to the word form in the non-PF condition, rather than, differences due to orthography-phonology mapping per se. Mitigating this concern, however, is the fact that the neural activation for EF vs. PF and CF vs. PF recruited the predicted neural regions involved in orthography-phonology mapping, rather than solely regions implicated in basic, early visual processing. This limitation is also relevant to the pseudoword comparisons. It is true that for EF, but not PF, the pseudoword was presented on the screen on each trial during the receipt of feedback, and thus one would expect habituation for pseudowords in the EF, but not the PF, condition. However, interestingly, the EF – PF contrast revealed neural activation in much of the same neural regions as the EF – CF contrast, where both EF and CF presented the pseudoword on each trial during the receipt of feedback. Thus, it unlikely that these results are due to repeated stimulus presentation in the Elaborative and Content, but not Positive Feedback conditions.

1.5.5 Implications

Elaborative feedback focuses on both skill-related content and praising instances of correct application of the skill. This contrasts with feedback that focuses primarily on skill-content alone. Implementing elaborative feedback requires that the educator seek positive behaviors and demonstrations of skill among learners, and subsequently communicate their observations to learners in a positive manner, thus promoting positive affect as well as future applications of the behavior. Concurrent activation of task-relevant and reward regions may, over time, increase an individual's positive affective experience of the target academic skill, thus addressing both cognitive and affective impediments to reading. In terms of neural consequences, activation of task-relevant regions during the receipt of feedback has the potential to enhance function in these regions over time, which is associated with improvements in reading performance.

Since the elaborative feedback used here helped readers who were already skilled, this raises the possibility that it may also help struggling readers. If future studies were to show that elaborative feedback similarly recruited reading-related neural regions among struggling readers, this could be potentially helpful, given that these individuals have been shown to have reduced activation of these brain regions during reading tasks (Maisog et al., 2008; Richlan et al., 2009). Conversely, improving reading skills has been shown to correspond to increasing activation in the same reading-related brain regions (Eden et al., 2004; Temple et al., 2003). Therefore, one implication of this study would seem to be that enhancing activation of these neural regions, as shown here during elaborative feedback, could potentially serve to improve reading skills among struggling readers. The rewarding aspect of elaborative feedback may be particularly beneficial in this process, as struggling readers often experience further detriments due to adverse affective reactions to low performance.

STUDY 2

2.1 Aim

To identify differences in resting state functional connectivity for individuals exposed to high compared to low levels of violence.

With high crime rates plaguing urban neighborhoods, it is essential that neuroscience research specifically look at the effects of this environmental stressor. Moreover, with low-income students scoring, on average, below their high-income peers, it is important to pay attention to the underlying causes of this discrepancy. Study 2 aims to do so by examining differences in resting state functional connectivity corresponding to reports of childhood exposure to violence, a stressor prevalent among low-income communities.

Resting state functional connectivity is defined as temporal correlations of fMRI time-series among distinct neural regions observed during the resting state (Biswal, Zerrin Yetkin, Haughton, & Hyde, 1995; Friston, 1994; van den Heuvel & Hulshoff Pol, 2010). Activity has been shown to be a measure of the organization and communication among neural regions (van den Heuvel & Pol, 2010). Neuroimaging research has demonstrated alterations in connectivity between frontal and subcortical regions for individuals exposed to acute and chronic stress, corresponding to differential reward and threat processing. However, no studies to our knowledge have examined the particular effects of high exposure to community violence on resting state functional connectivity. Thus, the second aim of the proposed research is to identify such effects on neural connectivity among frontal and subcortical regions implicated in reward and threat processing, thereby providing evidence on which to base future interventions.

Exposure to stress affects cognitive and affective processes, both of which have been shown to be involved in learning from feedback. Positive feedback has been shown to be rewarding and recruit affective neural processes (Delgado, Nystrom, Fissell, Noll, & Fiez, 2000; Hattie & Timperley, 2007), while working memory has been shown to be related to an individual's ability to learn from negative feedback as well as regulate emotion after such feedback (Schmeichel & Demaree, 2010). To investigate areas relevant to these functions, in Study 2 we chose two seed regions from feedback learning studies. We compared resting state connectivity from these regions for individuals exposed to high compared to low levels of violence.

2.2.1 Hypothesis 1

Relative to individuals exposed to low levels of violence, individuals exposed to high levels of violence are expected to demonstrate decreased functional connectivity between pre-frontal and sub-cortical areas.

2.2.2 Hypothesis 2

Relative to individuals exposed to low levels of violence, individuals exposed to high levels of violence are expected to demonstrate decreased connectivity between right dlPFC and other neural regions, such as parietal cortices, involved in working memory.

2.3 Methods

2.3.1 Participants

Thirty-one right-handed native English speakers were recruited from the Rutgers University – Newark community using the following sources: the undergraduate test participant pool, the Rutgers graduate student listserv, Craigslist, and flyers posted in several campus locations. Participants were combined across four separate studies conducted by the Language Behavior and Brain Imaging Laboratory, all of which collected resting state fMRI data in a separate run using identical acquisition parameters. All participants provided written informed consent according to Institutional Review Board guidelines and were compensated $30 per hour for their time in the scanner. Participants were prescreened to exclude those reporting a history of traumatic brain injury, psychiatric illness, diagnoses of learning disabilities, or attention deficit hyperactivity disorder. Participants were also screened based on self-report for current drug use, cigarette smoking, and more than moderate alcohol consumption. Participants were divided into two groups based on a median split of their self-report scores on an adapted version of the Survey of Exposure to Community Violence (SECV; Appendix B; Richters & Saltzman, 1990). Participants were selected for inclusion in one of two groups based on whether they reported being exposed to high levels of violence (HighViol) $M = 21.36$ ($SD = 6.18$), or low levels of violence (LowViol) $M = 5.73$ ($SD = 3.28$), $t(27)=8.58$, $p<.0001$.

In an attempt to isolate the neural effects of previous exposure to violence, the two groups were matched on numerous relevant variables. Continuous-valued variables were tested for differences between groups using t-tests, while categorical variables were tested using chi-square tests. There were no reliable differences between groups for the continuous-valued variables of age, current SES, verbal intelligence as estimated by the Wechsler Test of Adult Reading (WTAR, Wechsler, 2001), parental SES, and exposure to violence during the past year (all $p > 0.1$, Table 3). The HighViol group consisted of 14 individuals, with 7 females; the LowViol group consisted of 15 individuals, with 11 females, $\chi 2$ (1, N=27) = 0.83. Groups were also matched on race, $\chi 2$ (4, N=27) = 3.08, ethnicity, $\chi 2$ (3, N=27) = 3.64, and languages spoken (monolingual vs. bilingual), $\chi 2$ (1, N=27) < 0.0001 (all $p > 0.1$, Table 3).

	High Violence	Low Violence	P
N = 29	14	15	
Age	24.36	22.93	0.28
Gender	7 Females	11 Females	0.36
Verbal IQ	109.86 (12.53)	110.93 (11.14)	0.81
SES current	18.21 (2.94)	16.73 (2.43)	0.15
SES parental	14.58 (4.60)	12.00 (5.24)	0.32
Exp Viol Current	9.21 (7.18)	6.20 (4.80)	0.19
Exp Viol Childhood	21.53 (6.18)	11.14 (3.28)	<.001
Languages Spoken (Monlingual vs. bilingual)	11 monolingual 3 bilingual	11 monolingual 4 bilingual	1

Table 3: Individuals scoring above the median (High Violence) on the adapted version of the SECV (Richters & Saltzman, 1990) were matched to individuals scoring below the median (Low Violence) on the SECV on the variables above.

2.3.2 Procedure

Resting-state data were collected at the end of each scanning session (after completion of any task). Participants were told to lie still, look at the fixation cross, and let the mind wander. For one of the studies, participants completed relevant questionnaires by hand directly after the scan. For the other three studies, participants were contacted after they had participated in the study, and invited to complete the questionnaires online. All participants were administered the WTAR (Wechsler, 2001) verbal IQ (VIQ) estimate directly after the scan.

2.3.3 Behavioral measures

The Survey of Exposure to Community Violence (Richters & Saltzman, 1990) is a validated self-report measure that assesses an individual's incidence of being a victim of violence (e.g., Have you been hit or punched by someone?) as well as witnessing acts of violence (e.g., Have you heard guns being shot?). The full survey, which consists of 11 items assessing victimization and 35 assessing witnessing violence, has high test-retest reliability (.81, Richters & Martinez, 1993). In the current study, an adapted version was used, with 2 items assessing frequency of being a victim, and 13 items assessing frequency of witnessing violence. Four response choices are included for each question (1. Yes, many times; 2. Yes, a few times; 3. Yes, once or twice; 4. No.) Responses were reverse coded, with choice 4 receiving 0 points, and choice 1 receiving 4 points. Two items asking about helping behavior (e.g., Have other people helped you with something?) were not scored. Two copies of the survey were administered. For one, participants were asked to base their answers on their childhood experience during the ages of 3 to 14 years old (Appendix B). For the other, participants were asked to base their answers on their current experiences, during the last year (Appendix A).

The Modified Kuppuswamy SES scale was adapted from Kuppuswamy (1981). It is a three-item measure assessing education and occupation of the head of household, as well as per capita income (Appendix D). Seven response choices were provided for each question, with responses indicating high SES (e.g. "Professional") coded as 7, and low SES (e.g. "Unemployed") coded as 1. Thus, scores range from 3 to 21, with lower scores indicating lower SES (labeled “SES current” in Table 3). After administering this survey to twenty participants, it was determined that it would be additionally useful to obtain a measure of childhood SES. Therefore, an additional measure was administered based on the Reserve Capacity Model (Appendix F; Gallo, Bogart, Vranceanu, & Matthews, 2005). It asked participants to report household income, employment status, and highest level of educational attainment of their parent or guardian (labeled “SES parental” in Table 3). Nineteen out of the 31 participants completed this measure.

2.3.4 fMRI acquisition and analysis

MRI data were collected on a 3-T Siemens Magnetom TrioTim Scanner with a 12 channel head coil. A T1 high-resolution anatomical brain scan was collected for each participant, using a 3-dimensional magnetization-prepared rapid gradient-echo (MPRAGE) sequence, with a TR of 1900 milliseconds (ms) and a TE of 2.52 ms (matrix = 256 x 256 voxels, 176 contiguous 1 mm axial slices, field of view, FOV = 256 mm, flip angle = 9 degrees). A seven minute resting state scan of Blood Oxygen Level Dependent (BOLD) data was collected using a gradient-echo echoplanar imaging (EPI) sequence (TR = 3000 ms, TE = 31ms, FOV = 240 mm, matrix = 96 x 96 voxels, flip angle = 90 degrees) was obtained, yielding 140 axial slices with 2.5 x 2.5 x 2.5 mm voxel size.

All MRI data were preprocessed using the AFNI software suite (http://afni.nimh.nih.gov/afni; (Cox, 1996). Slice timing and motion correction were applied to the time series images, and the high-resolution structural scan was then aligned to these images (Saad et al., 2009). The first 6 images in each run were ignored due to initial saturation. High and low pass filtering at .01 and .1 Hz, respectively, were applied to the image time series. Signal in the ventricles and white matter, as well as the global mean, were modeled separately as nuisance regressors using the AFNI program for least squares multiple linear regression, 3dDeconvolve. Two seed ROIs, one in the vmPFC and one in the right dlPFC, were generated, as described in the next section, and then aligned to each subject's original resting state functional image space. The time series for each voxel was averaged for each ROI using the AFNI program 3dmaskave, and entered into an individual subject whole-brain analysis as the regressor of interest for each subject. Each subject's anatomical scan was aligned to the Talairach atlas (Talairach & Tournoux, 1988), and this alignment solution was applied to align each subject's image regression results to the same atlas. Group-level analysis was then conducted on these registered images for each condition using the AFNI program 3dttest++ to convert group-averaged functional connectivity coefficients into z-scores. A brain mask excluding most white matter and cerebrospinal fluid was applied to all resulting images. The group z-score images were thresholded at a voxelwise $p < 0.01$, with a cluster extent correction of 740 μl (mapwise corrected $p < .05$, as determined by the AFNI program 3dClustSim). Analyses were performed separately for the vmPFC and dlPFC seed regions.

2.3.5 Seed ROI generation

Two prefrontal ROIs were obtained from two different feedback studies. The vmPFC seed ROI (Figure 7a) was obtained from our previous study of the effect of type of feedback on reading novel word forms. The contrast of elaborative feedback, which contained both reward and task-specific skill components, with content feedback, which contained only the task-specific skill component, resulted in activation of the vmPFC

(Mattheiss et al., 2018). Thus, the resulting cluster in the vmPFC represented the effect of reward processing. This bilateral result was binarized to form the vmPFC seed ROI shown in Figure 7a.

The dlPFC ROI (see Figure 7b) was obtained from a different study examining the neural correlates of negative feedback (Zanolie, Van Leijenhorst, Rombouts, & Crone, 2008). This study demonstrated recruitment of the dlPFC ROI for negative, but not positive feedback. Moreover, this ROI was more active when errors were informative as to the correct answer on the following trial, suggesting its involvement in future goal-directed actions as well as working memory, which is thought to be required in order to learn from a previous error and apply a correct rule on a subsequent trial (Zanolie, Van Leijenhorst, Rombouts, & Crone, 2008). For the current study, the ROI was generated by creating a 6 mm sphere surrounding the coordinates used for the ROI in Zanolie et al. (2008), converted from MNI to Talairach as x = 43, y = 33, z = 31, and excluding any voxels outside the brain.

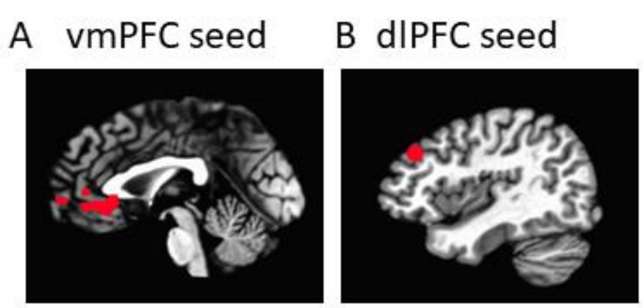


Figure 7a: Ventromedial prefrontal cortex (vmPFC) seed and (b) right dorsolateral prefrontal cortex (dlPFC) seed (centered at Talairach coordinates, x=43, y = 33, z = 31).

2.3.6 Feedback post-hoc analyses

Subjective ratings of feedback were examined for a subset (n=18) of the 31 subjects in this study who participated in our previous feedback study (Mattheiss et al., 2018) described above, in which participants learned to read aloud novel letter strings with different types of feedback. Relevant to the current analysis were the Elaborative feedback and Content feedback conditions, both given only for correct responses. For Elaborative feedback, participants were given positive reinforcement (in the form of praise) when they pronounced novel letter strings correctly, and paired with a repetition of how to produce the correct pronunciation. For Content feedback, participants were simply given a repetition of how to produce the correct pronunciation. The valence of Content feedback was ambiguous, as it did not explicitly indicate a correct or incorrect answer.

In this previous study, subjects were provided with a 5-item Likert questionnaire, asking them to rate the degree to which each type of feedback was rewarding. A two-tailed t-test was conducted for the subset of participants from the HighViol group and from the LowViol group who participated in the feedback study (HighViolSub and LowViolSub, respectively), using subjective ratings of Content feedback as the dependent variable. This was done to determine whether the HighViolSub compared to the LowViolSub rated the ambiguous Content feedback as less rewarding. To test whether this pattern differed for the Content compared to Elaborative feedback conditions, a two-way ANOVA was conducted, with feedback category and group entered as independent variables, as well as their interaction.

Next, to determine whether there were differences in regulation of the amygdala by the vmPFC during the receipt of feedback, an effective connectivity analysis was conducted on this same subset of participants. To avoid logical circularity, a different vmPFC cluster than the one used in the main analysis was generated. This cluster came from a second rsFc analysis using an anatomically-defined left amygdala seed region. Directional, or causal, connectivity between the vmPFC and the anatomically-defined left amygdala was computed for Elaborative, compared to Content, feedback. This was done for both the HighViol and LowViol groups. The raw time series data was averaged within each ROI using the FSL software (Jenkinson, Beckmann, Behrens, Woolrich, & Smith, 2012), fslmeants. The time series was then separated into distinct files corresponding to each feedback type, and entered into Independent Multisample Greedy Equivalence Search (IMaGES; Ramsey et al., 2010; Tetrad software package, Version 4.3.10-7, http://www.phil.cmu.edu/projects/tetrad).Candidate directed acyclic graphs were taken from the IMaGES step just described, and further analyzed to determine directionality of influence among the ROIs using Linear non-Gaussian Orientation, Fixed Structure (LOFS). This algorithm uses a non-Gaussianity measure and the property of linear models, in which the residuals of the correct model will be less Guassian than an incorrect model (Ramsey, Hanson, & Glymour, 2011). The degree of non-Guassianity was determined using the Anderson Darling test (Anderson & Darling, 1952).

2.4 Results

2.4.1 Ventromedial PFC resting state functional connectivity

First we established the overall connectivity patterns for each group, then contrasted the connectivity between groups. For both groups, the group analysis examining resting state functional connectivity between the vmPFC seed region and the whole brain resulted in positive connectivity with the vmPFC seed and the medial and orbital frontal cortex, areas of dorsal frontal cortex (superior frontal gyrus), bilateral amygdala, parahippocampal gyrus, caudate, anterior temporal lobe, angular gyrus, and posterior cingulate. It also showed negative functional connectivity with the dorsomedial frontal cortex, precuneus, lingual gyrus, lateral frontal cortex, bilateral insula, right thalamus, and right putamen (see Figure 8a).

Different from the LowViol group, the HighViol group also demonstrated negative connectivity between the vmPFC seed and the left thalamus, lentiform nucleus, and putamen (not visible in the surface projection figures).

The contrast of high minus low exposure to violence was expected to show weaker connectivity for the high exposure to violence group between the vmPFC seed and subcortical regions involved in reward and threat processing, such as the amygdala. In line with this hypothesis, this contrast yielded significantly less connectivity for high- compared to low-violence exposure in areas including the left amygdala, left inferior temporal gyrus, and bilateral parahippocampal gyrus (Figure 8b).

An additional analysis was conducted using exposure to childhood violence as a continuous factor and examining the relationship between individual scores and functional connectivity across the whole brain with the vmPFC seed. The results were in the same direction as the group contrast, with higher exposure to violence predicting decreased functional connectivity between the vmPFC seed and the left amygdala and bilateral parahippocampal gyrus. However, the results did not withstand the voxel-wise correction at $p < 0.01$. We expect that the difference between the continuous and group analysis results is due to added noise from the two participants whose exposure to childhood violence scores were at the median (14). Possibly due to increased noise, the continuous analysis had less power to detect a true effect.

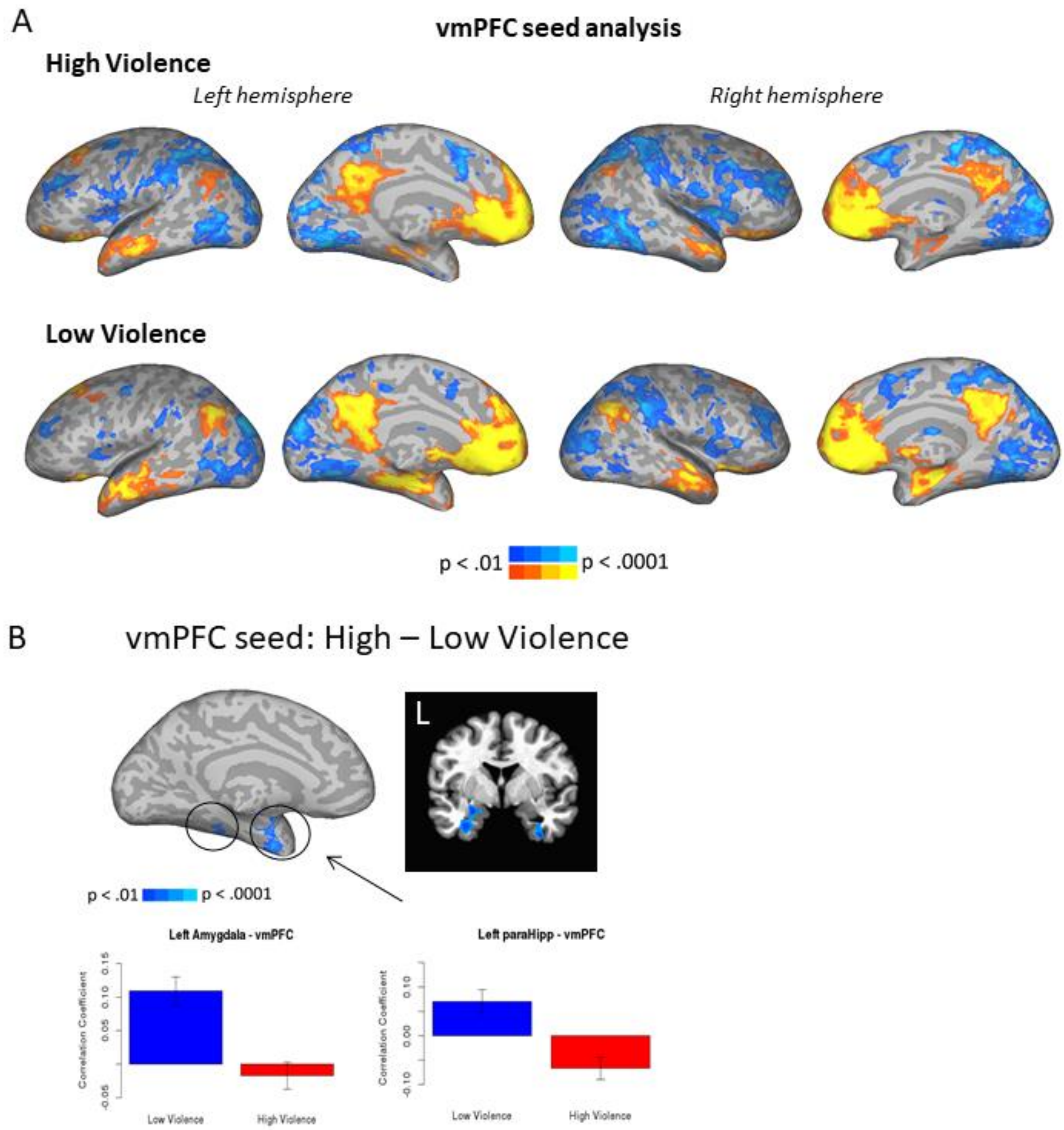


Figure 8a: Functional connectivity results from the vmPFC seed for the High and Low Exposure to Violence groups. b: The contrast of resting state functional connectivity with the vmPFC seed for High Violence - Low Violence. To illustrate the pattern of results, parameter estimates are plotted for the parts of the cluster falling within either the anatomically defined left amygdala (left panel), or the anatomically defined parahippocampal gyrus (right panel). The slice shows the result in volume space at y = 84.

2.4.2 Dorsolateral PFC seed resting state functional connectivity

For both the groups, exposed to low and high levels of violence, the group analysis examining resting state functional connectivity between the right dlPFC seed region and the whole brain resulted in positive connectivity with the lateral, dorsolateral, and dorsomedial frontal cortex as well as the bilateral superior parietal lobule (Figure 9a). However, only the group exposed to low levels of violence had positive connectivity between the dlPFC seed and the insula, thalamus, caudate head, precuneus, posterior cingulate, and fusiform gyri. Both groups also had significant negative connectivity between the dlPFC seed and the right amygdala and occipital cortex. The LowViol, but not the HighViol group, also had negative connectivity between the right dlPFC seed and the caudate tail (Figure 9a); whereas only the HighViol group demonstrated negative connectivity with the orbitofrontal and dorsomedial prefrontal cortex, left amygdala, left lentiform nucleus, bilateral putamen and caudate.

The contrast of high minus low exposure to violence was expected to result in decreased connectivity between the dlPFC seed and cortical regions involved in working memory, such as the IPS (Owen et al., 2005). In line with this hypothesis, this contrast yielded significant negative correlations bilaterally in the intraparietal sulcus and middle frontal gyrus (mapwise corrected $p < 0.05$, Figure 9b), with numerically larger cluster sizes in the right hemisphere. This contrast also yielded a significant negative correlation in a relatively posterior part of the right mid-cingulate cortex (Figure 9b).

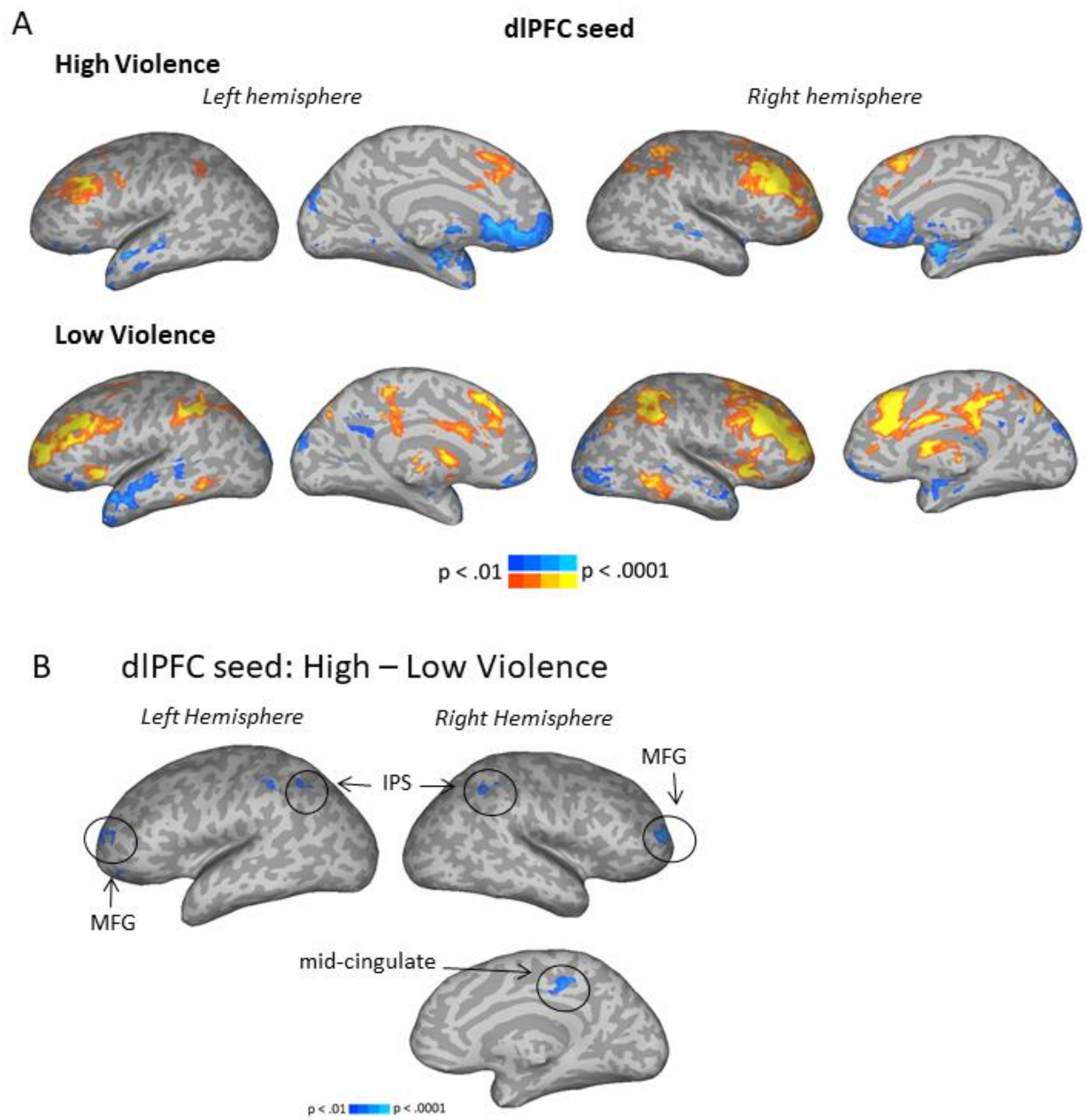


Figure 9a: Functional connectivity results from the dlPFC seed for the High and Low Exposure to Violence groups b: The contrast of rsFc with the right dlPFC seed for High Violence – Low Violence.

In addition to the median-split analysis, exposure to violence was entered as a continuous variable in a functional connectivity analysis using the dlPFC seed region. The results were robust, with significant overlap with the results of the group contrast.

High exposure to violence predicted increased connectivity between the right dlPFC seed and the bilateral IPS and MFG. To be consistent with the vmPFC analysis, however, the results shown here are those of the group analysis.

2.4.3 Follow-up analysis on effective connectivity during a feedback task

Having established differences in functional connectivity at rest across levels of exposure to violence, we sought to determine whether the resulting brain areas also showed differences in the direction of influence within the emotion regulation circuit. Specifically, we examined directional connectivity between the vmPFC and the left amygdala during feedback-based learning.

To define the vmPFC region, without risking circularity, additional functional connectivity analyses were conducted using anatomically defined left (Figure 10a) and right amygdala seeds. The pattern of group differences shown in Figure 9b were replicated for the left, but not the right amygdala seed. Notably, the left amygdala resulted in differences in a region of the vmPFC largely overlapping with our original vmPFC seed (Figure 10b).

First, a subset of the current participants who also participated in our previous study (N = 18) rated the feedback conditions in terms of affect. These were then compared between the high (HighViolSub) and low (LowViolSub) exposure to violence groups. Although Content feedback was rated as less rewarding across all participants (Mattheiss et al., 2018), we expected participants exposed to relatively high levels of violence to rate it as even less rewarding. A two-tailed t-test revealed a significant difference between groups, HighViolSub M = 2.75 (0.89), LowViolSub M = 3.80 (0.78), $t(17) = -2.62$, $p = 0.02$. A follow-up t-test on the more rewarding types of feedback, Elaborative and Positive, revealed no significant difference in reward ratings between groups, $p > 0.05$. However, an ANOVA revealed no significant interaction between group and feedback condition, $p > 0.05$.

Since Content feedback was rated overall as the least pleasant, with some evidence of even lower ratings among those exposed to high levels of violence, we expected individuals exposed to high levels of violence to have decreased regulatory activity, or decreased influence from the vmPFC to the amygdala, during this more negatively-rated feedback condition. Participants exposed to low levels of violence, on the other hand, would show a more typical direction of influence from the vmPFC to the amygdala during this feedback condition. The pattern of effective connectivity for the subset of participants from LowViolsub and HighViolsub was identical for Elaborative Feedback, with both groups showing connectivity from the vmPFC to the left amygdala (Figure 10c). However, for Content feedback, which was rated as less pleasant than Elaborative and Positive feedback, the two groups differed. The LowViolsub had causal connectivity from the vmPFC to the amygdala, exactly the same as in the Elaborative condition. But, the HighViolsub group had connectivity from the amygdala to the vmPFC (Figure 10c). Since the Content and Elaborative feedback conditions differed in that only the Elaborative contained a reward component, the differences between the LowViolsub and HighViolsub groups can be attributed to the differences in reward value. A third feedback condition, containing only positive feedback but not information about pronunciation, was also included in the previous study. For the sake of completeness, we also performed effective connectivity analysis on this condition; however, these results are more difficult to interpret, since the Positive feedback condition did not incorporate pronunciation content.

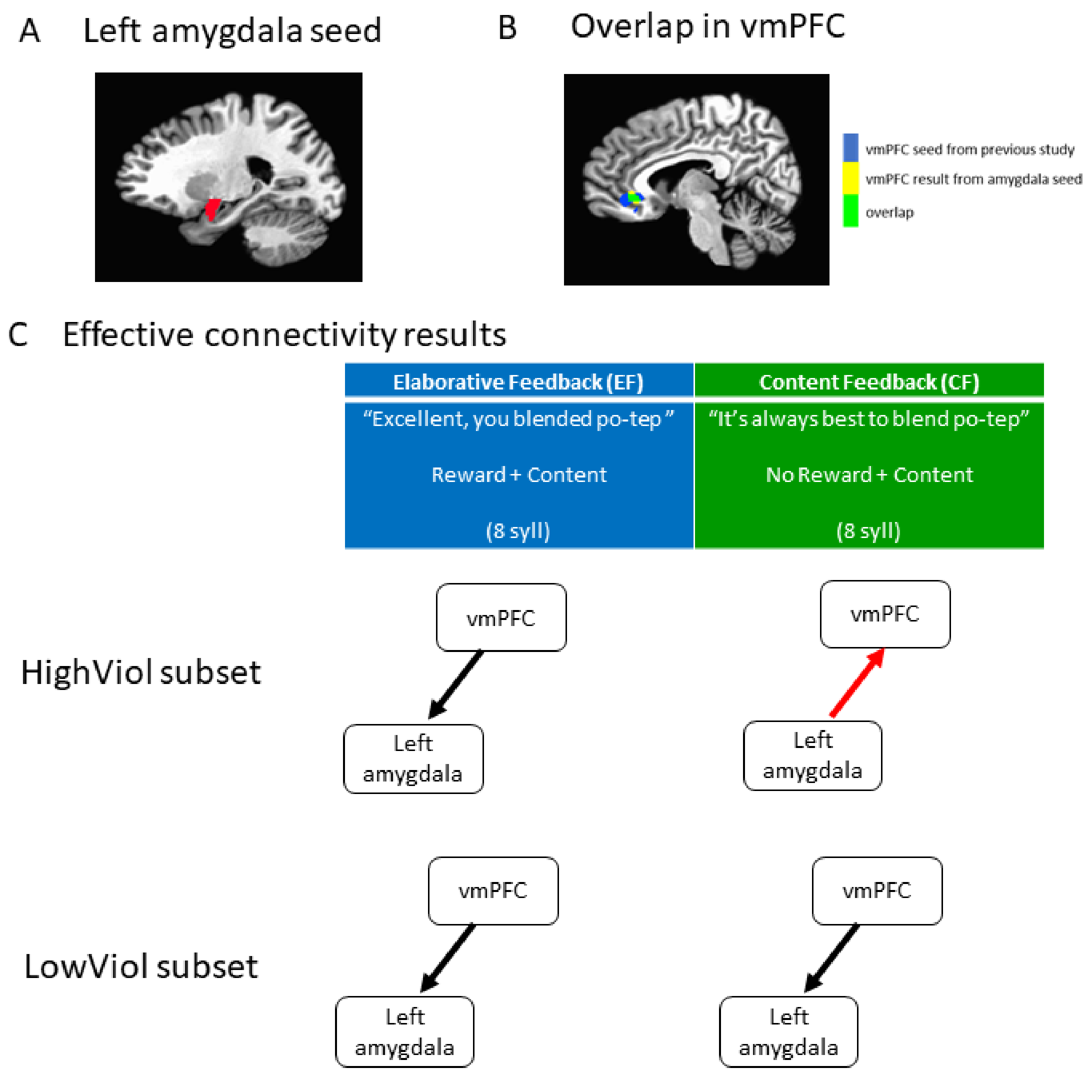


Figure 10a: The anatomically defined left amygdala seed. b: Logical conjunction of the vmPFC seed region (blue) and the vmPFC result from the rsFc group comparison with the anatomicaly defined left amygdala seed (yellow), showing spatially overlapping results (green). c: Results of the effective connectivity analysis for participants from the main analysis who had also participated in the previous feedback learning study.

2.5 Discussion

Low SES and other sources of early life stress have been shown to be related to differences in regulation of affect and cognition. The results of the current study suggest that, within comparable levels of SES, exposure to violence during development is specifically related to differences in emotion regulation circuitry of the type previously associated with early life stress more generally. In particular, participants reporting high, compared to low, levels of exposure to violence during childhood demonstrated less functional connectivity among prefrontal regions and subcortical regions implicated in the threat and reward response, as well as other regions implicated in working memory. Analyses based on seed regions from feedback learning studies also suggested that functional connectivity among regions involved in feedback learning may differ by exposure to violence. Further, the results of the effective connectivity analysis suggest that individuals exposed to high compared to low levels of violence may have decreased regulation of the amygdala by the vmPFC during the receipt of feedback that is content-informative but less rewarding than positive feedback. Overall, our results move beyond the effects of stress in general to specifically suggest that exposure to violence during development is related to differences in adult neural circuitry relevant to both affective and cognitive functioning.

2.5.1 Ventro-medial Prefrontal Cortex

Our current finding of decreased connectivity between the vmPFC and the left amygdala for individuals exposed to high compared to low levels of violence is consistent with previous evidence of reduced prefrontal-subcortical connectivity resulting from acute (Fan et al., 2015) and chronic stress (Malter-Cohen et al., 2013; Gee et al., 2013; Nooner et al., 2013; Thomason et al., 2015; Tottenham et al., 2010). Importantly, it is also in line with stress-induced increases in sensitivity to reward and threat processing (Kumar et al., 2014; Oei et al., 2012; van Marle, Hermans, Qin, & Fernández, 2009), which is thought to be related to decreased regulation of subcortical regions by prefrontal control regions (Banks, Eddy, Angstadt, Nathan, & Phan, 2007; Kim et al., 2013; Tottenham et al., 2010; Treadway, Buckholtz, & Zald, 2013). One study in particular demonstrated that after acute stress, participants had increased activity in the amygdala during reward anticipation (Kumar et al., 2014). The vmPFC has been shown to regulate neural activity in the amygdala, with reduced activity in the vmPFC as well as increased activity in the amygdala corresponding to increased levels of emotional reactivity (Hare et al., 2008; Shin et al., 2005). Thus, if connectivity from the vmPFC is weakened, the amygdala activates more in response to threatening stimuli. This is consistent with Tottenham et al. (2011), where children who experienced ELS had increased amygdala reactivity in response to threatening faces. The current study conceptually builds on these findings by providing evidence that exposure to violence during childhood results in similar alterations in neural connectivity in adulthood.

Decreased connectivity between vmPFC and amygdala for individuals exposed to high levels of violence is also consistent with research showing lower integrity of white matter tracts connecting frontal with medial temporal regions for children experiencing ELS (Eluvathingal et al., 2006; Kier, Staib, Davis, & Bronen, 2004) and reduced gray matter volume in the frontal cortex and hippocampus among children exposed to domestic violence (Tsavoussis, Stawicki, Stoicea, & Papadimos, 2014).

Decreased connectivity between the vmPFC and the bilateral parahippocampal gyrus is also consistent with previous findings (Demir-Lira et al., 2016), though fewer studies have found differences in prefrontal-parahippocampal connectivity due to stress exposure. Because the amygdala is known to be functionally connected to the parahippocampal gyrus (Cahill et al., 1996; Kilpatrick & Cahill, 2003), decreased connectivity from vmPFC to both the amygdala and parahippocampal gyrus is expected. Moreover, the amygdala has been shown to influence the parahippocampal cortex, especially in emotional learning contexts (Cahill et al., 1996; Kilpatrick & Cahill, 2003). Therefore, decreased connectivity between the vmPFC and both the amygdala and parahippocampal gyrus suggests that not only is the threat response (presumably supported by amygdala function) less regulated by the vmPFC, but also emotional learning (presumably supported by parahippocampal function) may be less regulated by the vmPFC. Such decreased connectivity between the vmPFC and parahippocampal gyrus for individuals exposed to high levels of violence aligns with previous evidence for stress-induced impairment in learning from negative feedback (Petzold et al., 2010). Specifically, decreased learning from negative feedback among stressed individuals may be related to increased responsiveness to the negative valence of the stimulus, thereby reducing resources available for learning. Similarly, among individuals exposed to high levels of violence, decreased connectivity between the vmPFC and amygdala and parahippocampal gyrus may similarly suggest increased reactivity to negatively valenced stimuli, and thus decreased neural resources available for learning of goal-relevant information.

The results of the post-hoc effective connectivity analysis showed influence from the amygdala to the vmPFC during the less rewarding feedback, for individuals exposed to high but not low childhood violence. This pattern is consistent with previous findings of increased amygdala response to threatening faces for individuals exposed to ELS (Gee et al., 2013; Tottenham et al., 2011). Although the less rewarding feedback was not necessarily “threatening,” it was ambiguous, as it did not indicate a correct answer. It therefore may have recruited the amygdala, which was then less regulated by the vmPFC for individuals who reported high exposure to violence during childhood. Previous research also shows decreased PFC activity during stress (Liston, McEwen, & Casey, 2009; Ossewaarde et al., 2011; Raio, Orederu, Palazzolo, Shurick, & Phelps, 2013) and negative affect (Johnstone et al., 2007; Urry et al., 2006). Evidence from the current effective connectivity analysis extends the implications of such previous research to feedback learning. In particular, causal connectivity from the amygdala to the vmPFC during the less rewarding feedback type suggests that individuals exposed to higher levels of violence during development may be less able to regulate the response of the amygdala under more negatively valenced learning conditions. Further, the results of the effective connectivity analysis suggest a relationship between decreased resting state functional connectivity between the vmPFC and left amygdala, and decreased regulation of the amygdala by the vmPFC during negatively valenced conditions.

Our study provides unique evidence demonstrating modulation of emotion-regulation circuitry by early exposure to violence. Critically, this was found to be distinct from SES. Therefore, while both low SES and exposure to violence can contribute to early life stress, the contribution of the current study is to begin to decompose the construct of stress into components, showing that early exposure to violence has a distinct impact on emotion regulation circuitry.

2.5.2 Dorso-lateral Prefrontal Cortex

The contrast of high compared to low violence exposure groups for the rsFc analysis showed decreased connectivity between the right dlPFC seed and the bilateral IPS and MFG. These regions have previously been shown to be involved in working memory (Manoach et al., 1997; Owen et al., 2005). The finding that they are associated with differences in stress levels is consistent with previous research as well. Specifically, studies have found deficiencies in working memory due to both chronic (Mizoguchi et al., 2000; Philip et al., 2016) and acute (Oei et al., 2012) stress. Moreover, general reductions in PFC functioning have been found among individuals with low SES (for review see Hackman & Farah, 2009; Hackman, Farah, & Meaney, 2010). While stress-induced behavioral and functional differences in the dlPFC have been shown previously, our study uniquely highlights modulation of connectivity among working memory regions by a specific violence-related component of stress.

While decreased connectivity from the right dlPFC to the mid-cingulate for the group of participants exposed to high levels of violence was not predicted, this finding is in line with previous evidence of involvement of the mid-cingulate in chronic pain and stress (Vogt, Berger, & Derbyshire, 2003). In one study, the mid-cingulate was recruited when participants were asked to identify a target stimulus in an emotionally negative context (following negative compared to neutral pictures; Pereira et al., 2010). Further, recruitment of the mid-cingulate corresponded to interference effects of negatively valenced stimuli (Pereira et al., 2010) and pain anticipation (Brown & Jones, 2008).

Exposure to violence has been shown to lead to deficits in academic (Burdick-will, Ludwig, Raudenbush, Sampson, & Sharkey, 2010; Sharkey et al., 2014), cognitive (Sharkey, 2010), and attentional performance (Sharkey et al., 2012). Along with our current finding, these results call for further attention to the mid-cingulate and its connectivity with the dlPFC as potentially playing a role in the deleterious cognitive consequences of exposure to violence during development.

The dlPFC is also relevant to the emotion regulation circuit in that it has been shown to mediate the relationship between the vmPFC and the amygdala (Hartley & Phelps, 2010). The current study builds on this by finding decreased functional connectivity in the high violence exposure group between the dlPFC seed and other working memory regions, as well as decreased functional connectivity with the vmPFC and amygdala. Overall this suggests that both affective and cognitive control networks may be altered due to exposure to violence. This points to the importance of addressing both domains in future studies that, for example, test interventions.

2.5.3 Limitations

Although this study has the potential to offer insight into the neural connectivity associated with exposure to violence, several limitations are present. For one, exposure to violence is typically higher in neighborhoods of lower SES (Sampson, 1997), and SES has been shown to correlate with multiple other environmental factors, such as exposure to environmental toxins (Krieger, Rowley, Herman, & Avery, 1993). Although SES was matched in our study, it is possible that other factors which co-occur with SES may also have differed between our groups. Exposure to violence may also affect other outcomes, such as level of physical activity (Molnar, Gortmaker, Bull, & Buka, 2004), and perceptions of social cohesion among neighbors (Sampson, 1997). As such, it may be that differences in connectivity between groups is attributable to other violence- or low SES-related factors. Exposure to violence may also be correlated with drug use and addiction (Sinha, 2008). However, in our sample, participants were prescreened based on self-report for no previous drug or alcohol abuse treatment, no current use of recreational drugs, and minimal alcohol consumption and/or cigarette smoking.

There were additional behavioral measures of potential interest, such as perceived stress, working memory abilities, and aggressive behaviors, that were not measured in this study. Thus, it cannot be concluded that the effects of exposure to violence are the same as, or different from, the effects of these variables. Further, the adapted version of the SECV (Appendix B; Richters & Saltzman, 1990) used in our study does not distinguish between exposure to family or partner violence compared to neighborhood violence. Therefore, the effects of exposure to violence in this study cannot be attributed to those more specific forms of violence.

Also, it is possible that individuals exposed to high levels of violence may, like those who experienced ELS, respond more to threatening stimuli, and therefore would perceive the scanner environment as being more threatening. Differential subjective experiences in the scanner would alter resting state neural connectivity. However, 13 out of our 31 participants (the question was added to the study at mid-point) were asked, "How threatened did you feel while in the fMRI scanner?" with choices ranging from 1) Not at all threatened; to 5) Extremely threatened. Ten out of these thirteen participants reported feeling "Not at all threatened," and three reported feeling "Slightly threatened."

Exposure to violence during childhood did not predict the degree to which participants felt threatened in the scanner, $F(1,10) = 0.56$, $B = 0.01$, $p > 0.05$. Thus, it is unlikely that differences in perception of threat in response to the scanner environment contributed to our results.

Additionally, although gender did not significantly differ by high and low exposure to violence, there was a numeric difference, with 7 females in the High Violence group, and 11 females in the Low Violence group. To test whether this small numeric difference in gender might be influencing the main results, a group analysis was conducted using the two seed regions, vmPFC and dlPFC, on females compared to males. Specifically, females compared to males had increased connectivity between the vmPFC and a region in the occipital cortex. And, less connectivity between the right dlPFC and the calcarine. Although there were small clusters in the occipital cortex that differed in connectivity to both the vmPFC and dlPFC for females compared to males, these regions did not overlap with the differences found in the main group comparison (High compared to Low Violence). Thus our results cannot be attributed to the numeric difference in gender between groups.

A final caveat is that this study of course cannot assert a causal relationship between exposure to violence and neural connectivity, since we did not experimentally manipulate exposure to violence. Instead, this study relied on self-report data. This leaves the possibility that some participants may have incorrectly recalled exposure to violence during their childhood years. However, the results of the current study do converge with experimental work examining the effects on neural activation of acute stress. For example, participants who received a stress manipulation, compared to control participants, had increased activity in the amygdala in response to both threatening and positively valenced facial expressions (van Marle et al., 2009). Stressed participants also show increased activity in the striatum and amygdala during reward consumption (Kumar at el., 2014), and decreased PFC activity during working memory tasks (Qin, Hermans, van Marle, Luo, & Fernández, 2009; Ossewaarde et al., 2011). These convergent findings point to the validity of the current results. If experiences of acute stress result in increased neural responses to threat and reward, with corresponding decreased PFC activity, it is logical that after prolonged exposure to stressors, the intrinsic functional connections between PFC control regions and affective subcortical and adjacent cortical regions would be reduced.

2.5.4 Implications

Here we have shown that individuals exposed to high levels of violence during childhood have decreased connectivity between the vmPFC and the left amygdala. In previous studies, decreased connectivity between vmPFC and the amygdala have been shown to be related to impairments in regulation of threat response (Hare et al., 2008; Shin et al., 2005; Tottenham & Sheridan, 2010). Thus, if individuals exposed to high levels of stress have less connectivity between the vmPFC and the left amygdala, they may also be less able to regulate attention and emotional reactions to negative or threatening information. In cases where negative feedback is seen as threatening, if we assume learning requires regulation of emotion, then stress-exposed individuals may be less able to learn from negative feedback. This is consistent with the results of the effective connectivity analysis, where individuals exposed to high levels of violence had decreased influence of the vmPFC on the amygdala during negatively valenced feedback. Moreover, the decreased connectivity found here between the right dlPFC seed, a region recruited for learning from negative feedback (Zanolie, Van Leijenhorst, Rombouts, & Crone, 2008), and other right lateralized working memory regions (Hampson, Driesen, Skudlarski, Gore, & Constable, 2006; Rowe, Toni, Josephs, Frackowiak, & Passingham, 2000; van Dam, Decker, Durbin, Vendemia, & Desai, 2015), such as the IPS , suggests that this altered neural circuitry may be related to working memory-dependent impairments in learning from negative feedback.

2.5.5 Conclusion and Future Directions

The current study provides a neural basis on which to further examine effectiveness of interventions that pair affective and cognitive skills for individuals exposed to high levels of stress, such as community violence. For example, the effectiveness of positive feedback for individuals exposed to violence could be tested to potentially provide evidence for the use of such feedback in classrooms where students are largely affected by community violence. Overall, this study demonstrates differences in neural connectivity due to exposure to violence, providing a neural basis for possible development of practical interventions, such as positive feedback and other forms of reward-based learning.

STUDY 3

3.1 Aim

To identify effectiveness and subjective reward value of feedback for individuals with increasing levels of exposure to violence.

Research demonstrates differential reward and threat sensitivity among stressed compared to unstressed individuals; while these behavioral and neural differences may be maladaptive in some circumstances, academic interventions that capitalize on such differences have potential to improve outcome for these individuals. For example, tapping into altered reward processing by pairing affective with cognitive interventions may promote academic skills. Specifically, by incorporating positive feedback with an essential literacy task, orthography-phonology conversion, individuals exposed to high levels of violence may demonstrate improvements in reading, thus closing the achievement gap and leading to multiple positive outcomes related to reading proficiency. If shown to be a successful intervention for these individuals, elaborative feedback may be paired with other academic skills with the goal of improving skill application and performance for these individuals.

The version of the Feedback study performed in the scanner (Study 1) offers initial support for the aim of Study 3. Specifically, in Study 1, there was a significant interaction between exposure to violence, as measured by the SECV (Richters & Saltzman, 1990), and pleasantness ratings of feedback conditions, $F(1,17)=4.82$, $p< 0.05$. Individuals exposed to high levels of violence rated Content Feedback as less pleasant, compared to Elaborative and Positive Feedback; this effect was in the same direction as that for individuals exposed to low levels of violence, yet with a stronger magnitude.

However, in this sample, exposure to violence was not a prescreened factor, and was correlated with age; yet when age was entered into the model, the interaction was still significant, $F(1,16)=6.96$, $p< 0.01$, suggesting that the effects hold above and beyond the effects of age. However, SES was an additional possible confound, with only current, and not childhood SES, measured. In Study 3, a more comprehensive measure of SES was used. Further, whereas in Study 1, subjective ratings were limited to "pleasantness" and "helpfulness" ratings, Study 3 included additional subjective measures, as discussed below in section 3.3 Methods.

Participants' reading ability was measured in Study 3 as well, to control for the effects of reading ability and also to examine differential responsiveness to feedback type for individuals differing in reading ability compared to those differing in exposure to violence. Differences in the effects of feedback for those with reading difficulty compared to those exposed to high levels of violence would point to the need for academic interventions designed specifically to address the effects of urban stressors; for example, by incorporating positive affective experiences in the classroom.

Finally, in this study, we attempted to isolate the effects of exposure to violence by accounting for several ancillary measures that would potentially affect accuracy for reading trained pseudowords, or interact with feedback category to predict accuracy. Specifically, we accounted for number of books participants reported having in the household while growing up, since number of books has been shown to predict early literacy skills (Johnson, Martin, Brooks-Gunn, & Petrill, 2008) has been shown to explain some of the SES-related differences in early reading achievement (Aikens & Barbarin, 2008). We also accounted for school quality, since the school quality has been shown to be typically poorer in low-SES communities (Lee & Burkam, 2002), as well, and evidence suggests that it affects later academic achievement (Heyneman & Loxley, 1983).

We took into account age as well as the interaction of age with feedback type, as previous studies have demonstrated an effect of age on feedback processing (Study1, Mattheiss et al., 2018; van Duijvenvoord, Zanolie, Rombouts, Raijmakers, & Crone, 2008). We also included gender and its interaction with feedback type, given previous evidence that males and females may respond differently to feedback depending on the presence of other motivational factors (Katz, Assor, Kanat-Maymon, & Bereby-Meyer, 2006; Nicaise, Cogérino, Bois, & Amorose, 2006).

Parental SES and interaction with feedback was included as well. This was done so that interaction of exposure to violence with feedback could be identified above and beyond the effects of low SES, since exposure to violence is more prevalent in low-income communities (Foster & Brooks-Gunn, 2009; Walker et al., 2011). We also accounted for current exposure to violence and interaction with feedback type, since we expected that current exposure would parallel the effects of childhood exposure to violence. We expected a similar pattern based on pilot data, but predicted a smaller effect of current exposure to violence, given that exposure to stressors during childhood and early adolescence has been shown to alter neural connectivity during key developmental periods (Luna, 2009; Tottenham & Sheridan, 2010). Current exposure to violence may also, at least intuitively, be related to lifestyle choices, such as drug use or involvement with aggressive peers; so the effects of current exposure to violence are potentially more likely to be confounded by other coexisting factors. Perceived stress was importantly accounted for, as stress has been shown to affect reward (Kumar et al., 2014; Nikolova, Bogdan, Brigidi, & Hariri, 2012) and feedback processing (Petzold et al., 2010; Treadway et al., 2013). We also wanted to distinguish the effects of exposure to violence from those of perceived stress.

The degree to which participants report ruminating on the violence events they experienced and the interaction of rumination with feedback was also included in the models. This was done so that the effects of exposure to violence could be distinguished from those of rumination on the violent events, which has been shown to increase psychological distress (Boyes, Hasking, & Martin, 2016; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008).

Previous research demonstrates that social support affects threat perception (Cohen & McKay, 1984; Schnall, Harber, Stefanucci, & Proffitt, 2008), which could be related to feedback if it were perceived as threatening; therefore, social support and its interaction with feedback type were included as well. We accounted for self-esteem and the interaction of self-esteem with feedback category. These terms were included because self-esteem has been shown to affect feedback processing, with people with low self-esteem more responsive to positive compared to negative feedback (Bernichon et al., 2003; Somerville et al., 2010).

Finally, we also sought to determine whether violence in the home or neighborhood, or both, contributed to the effects of violence. We didn't expect any differences between violence exposure in the home compared to the neighborhood, but these variables were included so that we would be able to better characterize our results as relating primarily to exposure to violence in the home, neighborhood, or both.

3.2.1 Hypothesis 1

Increasing exposure to violence during childhood is expected to interact with feedback type, such that increasing levels will predict higher accuracy for pseudowords trained with elaborative compared to content feedback.

3.2.2 Hypothesis 2

Increasing levels of exposure to violence during childhood is expected to interact with feedback type on subjective ratings, such that individuals reporting increasing levels of exposure to violence are predicted to rate Elaborative and Positive (both containing a reward component) as increasingly more rewarding compared to Content Feedback (containing a content, but no reward component).

3.3 Methods

3.3.1 Participants

Seventy-nine participants were recruited from the Rutgers University – Newark psychology undergraduate subject pool. The average age was 21.4 (7.27) years, 50 females, 25 males, and for 4 participants, gender was not reported. There were 32 monolingual English speakers, 32 bilingual speakers, and 15 did not report languages spoken. Average estimated verbal IQ (VIQ), measured by WTAR (Wechsler, 2001), was 105.32 (12.85), where the population average is 100. Subjects provided written Informed Consent according to Institutional Review Board guidelines. Participants received course credit for their participation.

3.3.2 Procedure

The feedback learning paradigm used in Study 1, which pairs Elaborative, Content, and Positive Feedback with pseudowords, was applied in Study 3 (see section 1.3, Study 1: Methods). However, a training phase was added to the beginning of the experiment, to ensure that participants understand the nonword reading aloud strategy. In the Training Phase, participants were presented with each vowel, and asked to state the long and short sounds associated with it. If incorrect, participants were provided with the correct responses. Vowel combinations were presented in the same way, and participants were told that the correct phonological representation for each vowel combination was the long vowel sound of either the first or second vowel. They were then provided with an opportunity to practice each of the vowel combinations, and asked to state the two possible phonological representations. If incorrect, the participant was told what the correct phonological representations were. Finally, participants were asked to "blend" the sounds together for two practice pseudowords, "nerut" and "jalim." They were instructed: "Now you will see an alien word appear on the screen. Try your best to sound it out, or blend together the sounds. Try to say it as many different ways as possible. Try the long and short sounds for both the first and second vowels." After their response, the four possible pronunciations, based on the instructions, were provided by the experimenter.

Further, in Study 1, only four pseudowords were paired with each feedback condition. In Study 3, this amount was doubled, with four additional one-syllable pseudowords also paired with each Feedback type (See Table 4 for list of pseudowords). This was done to maximize the number of trials to allow for greater power to detect an effect of feedback. One, rather than two syllable pseudowords were added in order not to make the task too difficult, as accuracy levels in Study 1 were somewhat low (57% total accuracy during the Testing Phase).

List	A	B	C
Pseudowords	baim chieve fumn zaight desut kegide tesib tinabe	bes chook fym zight botet kedene kopise terid	cheight doad jang zign bisob butib gilat tosote
Bigram Frequency	0.005 (0.002)	0.007 (0.003)	0.006 (0.003)
Biphone Frequency	0.005 (0.002)	0.004 (0.003)	0.005 (0.002)

Table 4: The full set of pseudoword stimuli used in the study, selected from Gupta et al. (2004), and surface characteristics controlled across lists. Standard deviations are in parentheses.

Additionally, rather than each nonword being trained with feedback on six consecutive trials, feedback was provided on the first three trials on which the participant responded correctly. Accuracy during Feedback was recorded as the number of incorrect trials, or the number of trials before the participant responded correctly.

After the nonword learning task, participants were administered the Test of Word Reading Efficiency – Second Edition (TOWRE-2; Torgesen, Wagner, & Rashotte, 2012) to obtain a general index of reading ability (Torgesen, Wagner, & Rashotte, 1999). From this point on, "reading ability" will be used to refer to scores on the TOWRE-2. Participants were also administered the WTAR (Wechsler, 2001) in order to obtain an estimate of verbal IQ; an assessment of SES including parental income, educational level, and employment (Gallo et al., 2005; Matthews, Gallo, & Taylor, 2010); two copies of the adapted version of the Survey of Exposure to Community Violence (Richters & Saltzman, 1990) used in Study 1, one measuring exposure to violence during the ages of 3 to 14, and the other measuring exposure to violence during the past year (Appendix A). Participants were also administered the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) in order to obtain an estimate of current levels of perceived stress. Parental SES (Appendix F) and Perceived Stress Scale scores were included as covariates in the main analysis.

In order to examine whether there were any differences based on whether the violence exposure was mainly in the home or in the neighborhood, two additional items on each of those surveys were included to assess the degree to which the violence reported was in the home or the neighborhood: "Please indicate the degree to which the exposure to violence you reported was in your home" and "Please indicate the degree to which the exposure to violence you reported was in your neighborhood" with five response choices ranging from "None at all" to "All." Another item was included to measure the degree to which participants ruminate on the violence events: "How often do you think about the violent events that you have experienced?" with five response choices ranging from "Never" to "Always." Responses to these questions were included in the main analyses, with the goal of parceling out the effects of home compared to neighborhood violence; and examining potential mediation of rumination of experiences of violence.

Additional measures of individual differences were included as prescreen measures: the Rosenberg Self Esteem scale (Rosenberg, 1979) and the Multidimensional Scale of Perceived Social Support (Zimet, Dahlem, Zimet, & Farley, 1988) scale.

Given that exposure to violence may coincide with other SES-related factors, participants were also asked to note the approximate number of books in their house while growing up, with seven response choices including the anchor points “None,” “1-20”, and “More than 100.” They were also asked to record all the schools they attended from Kindergarten to College, and then to rate the quality of schools they attended from PreK to 5th grade, 6th to 8th grade, and 9th to 12th grade.

Subjective ratings regarding participants' self-reported perception of each feedback type were obtained. Specifically, a Likert scale was administered asking participants to rate the degree to which each feedback type was 1) rewarding, 2) self-relevant, and 3) content-informative. An additional item was included on this measure (Appendix E), for each type of feedback, asking the participant, “To what degree did the following type of feedback make you feel like a good reader?” An example item is as follows: “To what degree did you find the following type of feedback rewarding? *Excellent, you got it correct*.” with seven response choices ranging from “1: Did not feel good at all,” to “7: Felt extremely good.”

3.3.3 Behavioral Analysis

Accuracy during the Testing Phase was scored as described in Study 1 as well, and used as the dependent variable in the model. Accuracy during the Feedback phase, recorded as the number of trials on which the participant responded incorrectly, was entered as a covariate, since this number indicates the participant's initial difficulty in reading aloud the nonword correctly. As such, accuracy during the Feedback phase was likely, as in Study 1, to have a significant effect on subsequent accuracy during the Testing Phase.

Performance data was analyzed with a linear mixed effects regression model, following the procedure used in Study 1, which was based on Baayen and colleagues (2008). Pseudoword and subject were entered as random variables, and the three types of feedback (EF, CF, and PF) entered as binarized variables. Languages spoken, number of books, school quality, age, gender, SES, current exposure to violence, perceived stress, reading ability, rumination on childhood violence, violence in the home, violence in the neighborhood, social support, self-esteem, and exposure to violence during childhood were entered as covariates.

The resulting coefficients represent the effect of each feedback condition on testing accuracy, adjusted for the covariate (accuracy during the Feedback Phase) and for random subject-level variance.

The model (Model 1a) was specifically formulated as follows:

$$\begin{aligned}\hat{y}_{Acc} = \; & b_{fAcc} + b_{Lang} + b_{NumBooks} + b_{SchoolQual} + b_{Age} + b_{Gender} + b_{SES} \\ & + b_{CurrViol} + b_{Stress} + b_{ReadAbility} + b_{RumChildViol} \\ & + b_{ViolHome} + b_{ViolNeigh} + b_{SocSupport} + b_{SelfEsteem} \\ & + b_{ChildViol} + b_{Feedbak} + w_{subj} + w_{word}\end{aligned}$$

A subsequent model was run which accounted for the interaction of age, gender, SES, current exposure to violence, perceived stress, reading ability, rumination on exposure to violence in childhood, violence in the home, violence in the neighborhood, social support, and self-esteem; and tested the interaction of exposure to violence during childhood with feedback category.

Model 1b:

$$
\begin{aligned}
\hat{y}_{Acc} = b_{fAcc} + b_{Lang} &+ b_{NumBooks} + b_{SchoolQual} + b_{Age} + b_{Gender} + b_{SES} \\
&+ b_{CurrViol} + b_{Stress} + b_{ReadAbility} + b_{RumChildViol} \\
&+ b_{ViolHome} + b_{ViolNeigh} + b_{SocSupport} + b_{SelfEsteem} \\
&+ b_{ChildViol} + b_{Feedbak} + b_{Age\ X\ Feed} + b_{Gender\ X\ Feed} \\
&+ b_{SES\ X\ Feed} + b_{CurrViol\ X\ Feed} + b_{Stress\ X\ Feed} \\
&+ b_{ReadAbility\ X\ Feed} + b_{RumChildViol\ X\ Feed} + b_{ViolHome\ X\ Feed} \\
&+ b_{ViolNeigh\ X\ Feed} + b_{SocSupport\ X\ Feed} + b_{SelfEsteem\ X\ Feed} \\
&+ b_{ChildViol\ X\ Feed} + w_{subj} + w_{word}
\end{aligned}
$$

An additional model was tested to determine whether there was an interaction among childhood exposure to violence, reading ability, and feedback condition.

Model 1c:

$$
\begin{aligned}
\hat{y}_{Acc} = b_{fAcc} + b_{Lang} &+ b_{NumBooks} + b_{SchoolQual} + b_{Age} + b_{Gender} + b_{SES} \\
&+ b_{CurrViol} + b_{Stress} + b_{ReadAbility} + b_{RumChildViol} \\
&+ b_{ViolHome} + b_{ViolNeigh} + b_{SocSupport} + b_{SelfEsteem} \\
&+ b_{ChildViol} + b_{Feedbak} + b_{Age\ X\ Feed} + b_{Gender\ X\ Feed} \\
&+ b_{SES\ X\ Feed} + b_{CurrViol\ X\ Feed} + b_{Stress\ X\ Feed} \\
&+ b_{ReadAbility\ X\ Feed} + b_{RumChildViol\ X\ Feed} + b_{ViolHome\ X\ Feed} \\
&+ b_{ViolNeigh\ X\ Feed} + b_{SocSupport\ X\ Feed} + b_{SelfEsteem\ X\ Feed} \\
&+ b_{ChildViol\ X\ Feed} + b_{ChildViol\ X\ ReadAbility} \\
&+ b_{ChildViol\ X\ ReadAbility\ X\ Feed} + w_{subj} + w_{word}
\end{aligned}
$$

Two separate linear regression models were used to test whether feedback category predicted subjective reward ratings. First, to confirm that EF and PF were rated as more rewarding than CF, which would replicate the results of Study 1, languages spoken, number of books, school quality, age, gender, SES, current exposure to violence, perceived stress, reading ability, rumination on childhood violence, violence in the home, violence in the neighborhood, social support, self-esteem, and exposure to violence during childhood were entered as covariates. Exposure to childhood violence was entered as a continuous variable, with feedback type coded as a binary variable.

Model 2a:

$$\hat{y}_{reward} = b_{Lang} + b_{NumBooks} + b_{SchoolQual} + b_{Age} + b_{Gender} + b_{SES} + b_{CurrViol} + b_{Stress} + b_{ReadAbility} + b_{RumChildViol} + b_{ViolHome} + b_{ViolNeigh} + b_{SocSupport} + b_{SelfEsteem} + b_{ChildViol} + b_{Feedbak} + w_{subj}$$

Next, another model was tested which additionally accounted for the interaction of each of these variables with feedback type: gender, SES, current exposure to violence, perceived stress, reading ability, rumination on exposure to violence in childhood, violence in the home, violence in the neighborhood, social support, and self-esteem; and tested the interaction of exposure to violence during childhood with feedback category.

Model 2b:

$$\hat{y}_{reward} = b_{Lang} + b_{NumBooks} + b_{SchoolQual} + b_{Age} + b_{Gender} + b_{SES} + b_{CurrViol} + b_{Stress} + b_{ReadAbility} + b_{RumChildViol} + b_{ViolHome} + b_{ViolNeigh} + b_{SocSupport} + b_{SelfEsteem} + b_{ChildViol} + b_{Feedbak} + b_{Age\ X\ Feed} + b_{Gender\ X\ Feed} + b_{SES\ X\ Feed} + b_{CurrViol\ X\ Feed} + b_{Stress\ X\ Feed} + b_{ReadAbility\ X\ Feed} + b_{RumChildViol\ X\ Feed} + b_{ViolHome\ X\ Feed} + b_{ViolNeigh\ X\ Feed} + b_{SocSupport\ X\ Feed} + b_{SelfEsteem\ X\ Feed} + b_{ChildViol\ X\ Feed} + w_{subj}$$

3.4 Results

3.4.1 Accuracy

EF was expected to result in the highest accuracy, compared to CF and PF. Specifically, pseudowords trained with EF compared to CF were expected to be read with higher accuracy during the Testing Round. Our results, however, did not support this prediction, with no significant difference in Testing Accuracy by feedback type, $F(1,2) = 0.05$, $p = 0.97$ (see Table 5 for accuracy; Table 3.3, Model 1a for coefficients).

This result was somewhat surprising, since previous studies demonstrated a significant effect of feedback type on Accuracy. Since this study included single syllable pseudowords as well as two-syllable pseudowords, while Study 1 used only two syllable pseudowords, the model was updated to test whether there was an interaction of feedback type and number of syllables:

Model 1a-updated:

$$\hat{y}_{acc} = b_{fAcc} + b_{Lang} + b_{NumBooks} + b_{SchoolQual} + b_{Age} + b_{Gender} + b_{SES} + b_{CurrViol} + b_{Stress} + b_{ReadAbility} + b_{RumChildViol} + b_{ViolHome} + b_{ViolNeigh} + b_{SocSupport} + b_{SelfEsteem} + b_{ChildViol} + b_{Feedbak} + b_{NumSyll} + b_{NumSyll\ X\ Feedback} + w_{subj} + w_{word}$$

There was no significant interaction between feedback type and syllables, $F(1,2) = 0.26$, $p = 0.77$. However, the pattern of accuracy for two syllable words more closely reflected that of Study 1, with EF compared to CF predicting higher accuracy when paired with two syllable words (see Table 5 for accuracy; Table 6 Model 1a-updated for coefficients).

An interaction between Feedback Condition and Exposure to Violence was also expected, with individuals exposed to high levels of violence expected to benefit more from EF compared to CF, compared to those exposed to low levels of violence, due to the reward value of EF. Although EF was more effective for increasing levels of exposure to violence in childhood, the effect was not significant, $F(1,2) = 1.0$, $p = 0.37$ (for coefficients, see Table 6 Model 1b).

However, since this study utilized a nonword learning task which relied on reading ability, the interaction of reading ability with exposure to violence and feedback type was also examined. A 3-way interaction was expected, with effects of EF potentially greater for good readers exposed to high levels of violence; such results would suggest that EF may be a successful intervention for individuals whose performance is specifically affected by exposure to violence. In this model, reading ability had a marginal effect, $p < 0.1$ on testing accuracy; reading ability interacted with feedback type such that higher reading ability predicted decreased accuracy on items trained with EF compared to CF, $p < 0.05$; childhood violence and feedback type significantly interacted, with decreased accuracy for items trained with EF compared to CF, for increasing levels of exposure to childhood violence, $p < 0.05$ (for coefficients, see Table 6, Model 1c). Finally, the three way interaction of childhood violence with reading ability and feedback type was significant, $F(1,2) = 3.27$, $p < 0.05$ (Table 6, Model 1c). In the regression model, the coefficient for the interaction of reading ability, exposure to violence, and elaborative, compared to content, feedback, was $B = 0.001$, $t = 2.54$, $p < 0.05$, showing that for high reading ability and high childhood violence, items trained with EF were read aloud more accurately than those trained with CF (see Table 6, Model 1c; Figure 11).

	Feedback Accuracy			**Testing Accuracy**		
EF	1.990 (3.191)	One syl	1.092 (2.262)	0.668 (0.471)	One syl	0.791 (0.407)
		Two syl	2.879 (3.694)		Two syl	0.544 (0.499)
CF	2.105 (3.204)	One syl	1.241 (2.534)	0.666 (0.472)	One syl	0.820 (0.385)
		Two syl	2.974 (3.558)		Two syl	0.512 (0.501)
PF	2.062 (3.317)	One syl	1.229 (2.629)	0.666 (0.472)	One syl	0.801 (0.400)
		Two syl	2.895 (3.705)		Two syl	0.532 (0.500)

Table 5: Feedback and testing accuracy for pseudowords trained with Elaborative (EF), Content (CF), and Positive Feedback (PF), across one and two syllable pseudowords. Feedback and testing accuracy for one and two syllable pseudowords trained with Elaborative (EF), Content (CF), and Positive Feedback (PF).

Parameter	**Model 1**	**Model 1b**	**Model 2**	**Model 3**
Intercept	0.881*** (< 0.001)	0.977*** (0.001)	0.852*** (0.001)	0.693* (0.02)
Feedback Accuracy	0.044*** (< 0.001)	0.044*** (< 0.001)	0.044*** (< 0.001)	0.044*** (<0.001)
Languages	0.009 (0.68)	0.009 (0.68)	0.010 (0.68)	0.010 (0.67)
Number of Books	0.000 (0.96)	0.000 (0.96)	0.000 (0.96)	-0.001 (0.94)
School Quality	-0.006 (0.71)	-0.006 (0.71)	-0.006 (0.71)	-0.003 (0.82)
Age	-0.005* (0.03)	-0.005 (0.32)	-0.005 (0.12)	-0.005 (0.13)
Gender	0.034 (0.33)	0.034 (0.33)	0.043 (0.39)	0.047 (0.35)
Parental SES	0.000 (0.86)	0.000 (0.86)	-0.001 (0.93)	-0.001 (0.81)
Current Violence	-0.001 (0.61)	-0.001 (0.61)	-0.003 (0.44)	-0.003 (0.50)
Stress	-0.001 (0.61)	-.001 (0.61)	0.000 (0.91)	0.000 (0.95)
Reading ability	0.004* (0.03)	0.004' (0.03)	0.005' (0.06)	0.008' (0.05)
Rumin. on Child. Viol.	0.030 (0.36)	0.030 (0.36)	0.057 (0.22)	0.046 (0.34)
Child. Viol. in Home	-0.021 (0.31)	-0.021 (0.31)	-0.029 (0.34)	-0.022 (0.48)
Child. Viol. in Neighborhood	-0.039 (0.97)	-0.039 (0.10)	0.006 (0.87)	0.007 (0.83)
Social Support	-0.001 (0.18)	-0.002 (0.18)	-0.002 (0.32)	-0.002 (0.27)
Self-esteem	-0.003 (0.16)	-0.003 (0.16)	-0.003 (0.30)	-0.003 (0.31)
Childhood Violence	0.004 (0.20)	0.004 (0.20)	0.000 (0.96)	0.015 (0.31)
Elaborative Feedback (EF)	0.001 (0.96)	-0.011 (0.75)	0.051 (0.87)	0.501 (0.16)
Positive Feedback (PF)	0.005 (0.83)	-0.011 (0.74)	0.043 (0.89)	0.219 (0.54)
Two Syllables		-0.196** (0.01)		
Two Syllables: EF		0.024 (0.61)		
Two Syllables: PF		0.034 (0.48)		
Age: EF			0.001 (0.76)	0.001 (0.81)
Age: PF			0.000 (0.88)	-0.001 (0.87)
Gender: EF			0.012 (0.84)	0.005 (0.93)
Gender: PF			-0.041 (0.51)	-0.046 (0.46)
SES: EF			0.008 (0.27)	0.010 (0.15)
SES: PF			-0.004 (0.57)	-0.003 (0.67)
Current Violence: EF			0.000 (0.93)	-0.001 (0.89)
Current Violence: PF			0.004 (0.36)	0.004 (0.41)
Stress: EF			-0.002 (0.68)	-0.003 (0.55)
Stress: PF			-0.001 (0.83)	-0.001 (0.75)
Reading ability: EF			-0.002 (0.63)	-0.012* (0.02)
Reading ability: PF			-0.001 (0.78)	-0.005 (0.33)
Rum. on Child. Viol.: EF			-0.035 (0.55)	-0.002 (0.97)
Rum. on Child. Viol.: PF			-0.046 (0.42)	-0.031 (0.60)
Child. Viol in Home: EF			-0.003 (0.94)	-0.023 (0.54)
Child. Viol in Home: PF			0.025 (0.50)	0.019 (0.63)
Child Viol in Neigh: EF			-0.051 (0.94)	-0.058 (0.17)
Child. Vio. in Neigh.: PF			-0.083' (0.5)	-0.082' (0.05)
Social Support: EF			0.000 (0.83)	0.000 (0.98)
Social Support: PF			0.000 (0.73)	0.001 (0.63)
Self-esteem: EF			-0.001 (0.77)	-0.001 (0.74)
Self-esteem: PF			0.002 (0.66)	0.002 (0.68)
Childhood Violence: EF			0.006 (0.32)	-0.040* (0.04)
Childhood Violence: PF			0.008 (0.17)	-0.010 (0.59)
Reading ability: Child. viol.				0.000 (0.28)
Reading ability: Child. viol.: EF				0.001* (0.01)
Reading ability: Child. viol.: PF				0.000 (0.31)

Table 6: Coefficients for parameters in each of the four models tested on accuracy. CF is

*the reference variable such that the effects shown for EF and PF represent the effects relative to CF. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ' $p < 0.10$*

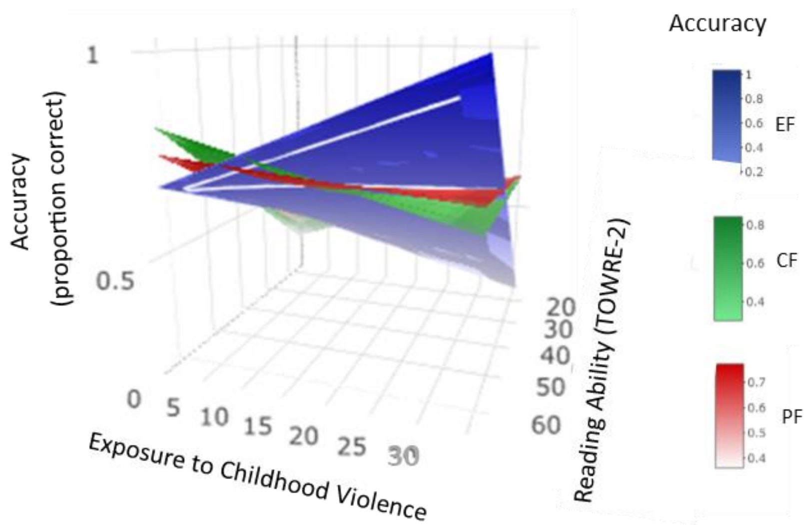


Figure 11: The interaction of reading ability, measured by scores on TOWRE-2 (Torgesen, Wagner, & Rashotte, 2012) *and exposure to childhood violence. Increasing levels of reading ability and increasing exposure to violence predicted higher accuracy for pseudowords trained with Elaborative Feedback (EF, blue), compared to Content Feedback (CF) and Positive Feedback (PF).*

Our final model for testing predictors of accuracy (Model 1c) allowed us to thoroughly investigate other factors related to the effects of exposure to violence. Bivariate, zero-order correlations among these variables are reported in Table 7. Since elementary, middle, and high school quality were highly correlated, a composite "school quality" score was obtained by averaging responses to the three items.

	Age	VIQ	Reading Ability	Child Viol	Curr Viol	Curr Viol Ru-min	Curr Viol Home	Curr Viol Neigh	Child Viol Home	Child Viol Neigh	Child Viol Rumin	SES	Stress	Self-esteem	Social Support	Number of Books	Elem School Quality	Middle School Quality	High School Quality
Age																			
VIQ	-0.11																		
Reading Ability	-0.15	0.46																	
Child Viol	0.10	0.12	0.03																
Curr Viol	-0.21	0.01	-0.01	0.58															
Curr Viol Rumin	0.10	**0.26**	-0.10	0.07	0.00														
Curr Viol Home	0.12	-0.02	-0.22	**0.25**	**0.25**	-0.08													
Curr Viol Neigh	-0.22	0.07	-0.13	**0.24**	**0.43**	0.01	0.14												
Child Viol Home	-0.04	0.15	0.05	**0.33**	0.17	-0.10	**0.56**	0.07											
Child Viol Neigh	-0.02	0.13	-0.06	**0.52**	**0.32**	0.03	0.08	**0.36**	0.14										
Child Viol Rumin	0.00	**0.23**	0.03	0.09	-0.04	**0.81**	**-0.24**	-0.09	-0.10	-0.04									
SES	**-0.25**	0.16	0.10	-0.08	0.19	0.07	-0.04	-0.03	-0.07	-0.08	0.05								
Stress	**-0.35**	0.20	-0.08	0.16	**0.31**	0.09	0.10	**0.33**	0.21	0.16	-0.02	0.07							
Self-esteem	0.19	-0.14	0.11	-0.04	-0.20	0.01	0.13	-0.20	0.02	-0.17	0.01	0.17	**-0.43**						
Social Support	-0.03	-0.14	0.18	**-0.26**	-0.13	0.03	-0.15	-0.20	**-0.27**	**-0.41**	0.04	**0.32**	**-0.28**	**0.39**					
Number of Books	0.05	0.16	-0.09	0.19	0.10	-0.07	0.16	0.07	0.05	0.20	-0.21	0.01	0.19	-0.17	0.02				
Elem School Quality	0.08	-0.03	-0.09	**-0.28**	-0.13	**0.24**	-0.04	-0.06	-0.18	-0.18	0.18	0.08	0.03	-0.05	**0.26**	0.00			
Middle School Quality	0.05	-0.05	-0.01	-0.01	0.04	-0.03	0.09	0.01	0.04	-0.13	-0.04	-0.07	0.20	-0.10	0.05	0.11	**0.58**		
High School Quality	-0.18	-0.02	-0.02	-0.11	0.00	0.03	-0.11	-0.11	-0.05	**-0.25**	0.11	0.14	-0.03	0.03	0.13	-0.11	**0.46**	**0.43**	

Table 7: Correlation matrix for all continuous variables. Significant correlations, at $p < 0.05$, are in BOLD font.

In addition to the significant effects discussed above, no additional covariates had a significant effect on testing accuracy. Null effects of languages spoken (monolingual or multilingual), number of books in household during childhood, school quality, age, gender, parental SES, current exposure to violence (during the past year), perceived stress, rumination on childhood violence, the degree to which childhood violence was experienced in the home or neighborhood, social support, and self-esteem, all $p > 0.05$, are shown in Table 6. There were also no significant interactions between feedback type and any of the following variables on testing accuruacy: age, gender, parental SES, current exposure to violence (during the past year), perceived stress, rumination on childhood violence, the degree to which childhood violence was experienced in the home or neighborhood, social support, and self-esteem, all $p > 0.05$ (Table 6).

3.4.2 Subjective Ratings

EF and PF were expected to be rated as more rewarding than CF, thus replicating the results of Study 1. Results supported this prediction, with the linear regression model yielding a significant effect of feedback category on reward ratings, $F(2,70) = 45.20$, $p < 0.001$. The regression model indicates that specifically, both EF and PF were rated as more rewarding than CF (see Table 8 Model 2a, Figure 12a).

The difference in subjective ratings for reward between EF and PF compared to CF was expected to increase by exposure to violence. Specifically, individuals exposed to high levels of violence were expected to rate CF as less rewarding than EF and PF, with a greater difference between conditions than individuals exposed to low levels of violence. The linear model supported this prediction, with a significant interaction between childhood violence and feedback type, $F(2, 70) = 4.93$, $p < 0.01$. Subjects reporting higher levels of childhood violence rated EF more rewarding than CF, $B = 0.11$, $p < 0.01$; and, subjects reporting higher levels of childhood violence rated PF more rewarding than CF, $B = 0.094$, $p < 0.05$ (see Table 8 Model 2b; Figure 12b).

	Model 2a	Model 2b
Intercept	3.815 (0.08)	5.615* (0.02)
Languages	0.021 (0.28)	0.026 (0.29)
Number of Books	-0.151' (0.07)	-0.151* (0.07)
School Quality	0.056 (0.56)	0.057 (0.55)
Age	0.016 (0.40)	0.007 (0.73)
Gender	0.223 (0.43)	-0.265 (0.59)
Parental SES	0.039 (0.22)	-0.045 (0.43)
Current Violence	-0.010 (0.77)	0.031 (0.31)
Stress	-0.037 (0.12)	-0.059' (0.05)
Reading ability	-0.007 (0.62)	-0.002 (0.84)
Rumin. on Child. Viol.	0.198 (0.62)	0.178 (0.72)
Child. Viol. in Home	-0.096 (0.65)	-0.128 (0.61)
Child. Viol. in Neighborhood	-0.261 (0.27)	-0.053 (0.87)
Social Support	-0.001 (0.82)	0.016 (0.33)
Self-esteem	0.016 (0.35)	0.009 (0.62)
Childhood Violence	0.038 (0.21)	-0.029 (0.50)
Elaborative Feedback (EF)	1.171*** (< 0.001)	-1.366 (0.51)
Positive Feedback (PF)	1.476*** (< 0.001)	-1.751 (0.66)
Age: EF		0.016 (0.51)
Age: PF		0.010 (0.66)
Gender: EF		0.780' (0.06)
Gender: PF		0.739' (0.06)
SES: EF		0.141** (0.001)
SES: PF		0.112** (0.01)
Current Violence: EF		-0.044 (0.16)
Current Violence: PF		-0.076* (0.02)
Stress: EF		0.023 (0.45)
Stress: PF		0.045 (0.15)
Reading ability: EF		-0.012 (0.53)
Reading ability: PF		-0.002 (0.91)
Rumin. on Child. Viol. EF		-0.096 (0.79)
Rumin. on Child. Viol: PF		0.117 (0.74)
Child. Viol. in Home: EF		0.035 (0.87)
Child. Viol. in Home: PF		0.040 (0.87)
Child. Viol. in Neighborhood: EF		-0.386 (0.18)
Child. Viol. in Neighborhood: PF		-0.285 (0.28)
Social Support: EF		-0.025' (0.07)
Social Support: PF		-0.027' (0.06)
Self-esteem: EF		0.007 (0.77)

Self-esteem: PF	0.016 (0.52)
Childhood Violence: EF	0.111** (0.003)
Childhood Violence: PF	0.094* (0.01)

*Table 8: The coefficients for parameters tested in Models 2a and 2b on subjective reward ratings. CF is the reference variable such that the effects shown for EF and PF represent the effects relative to CF. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ' $p < 0.10$*

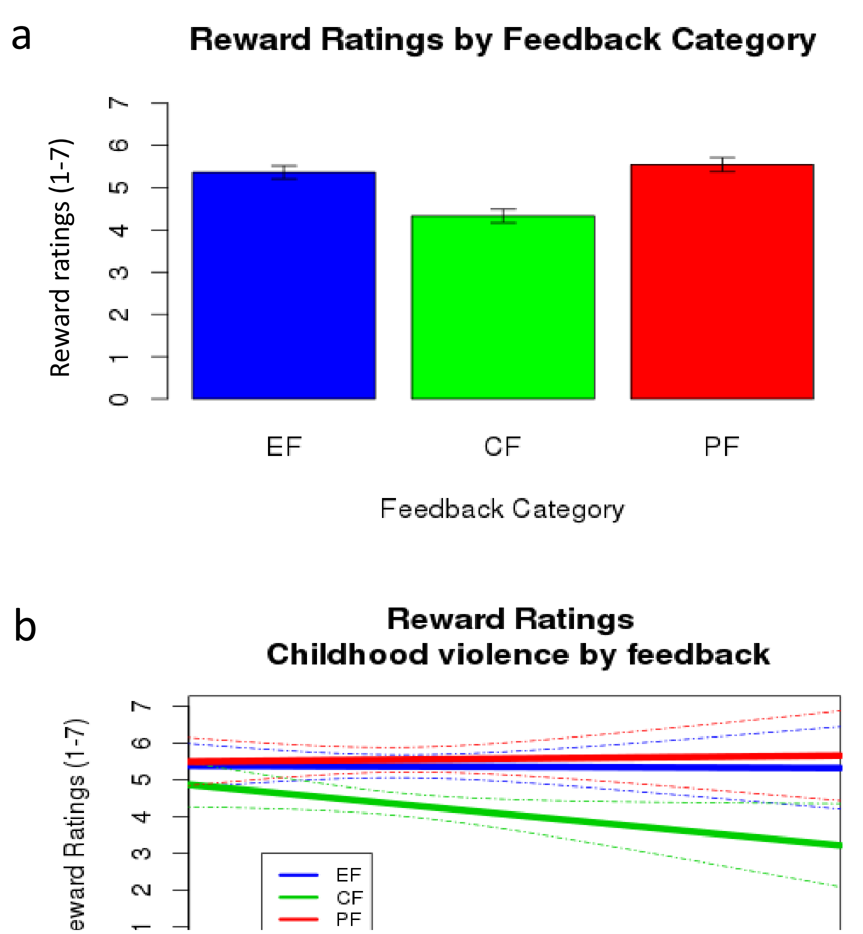


Figure 12a: Subjective reward ratings by feedback category. b: Increasing levels of exposure to violence predicted higher reward ratings for Elaborative (EF) and Positive (PF) compared to Content Feedback (CF).

To be thorough in our analyses, a number of other potential mediating factors were included in the model on reward ratings. The results are reported in Table 8. Among the significant findings, stress had a main effect on reward ratings as well, with higher levels of perceived stress predicting overall decreased reward ratings across feedback types. SES interacted with feedback type as well, with higher levels of SES predicting higher reward ratings for Elaborative compared to Content Feedback, $p < 0.01$, and Positive compared to Content Feedback, $p < 0.05$. Current violence predicted lower reward ratings for Positive compared to Content Feedback, $p < 0.05$. Social support marginally predicted lower reward ratings for Elaborative and Positive, compared to Content feedback, both $p < 0.1$.

There were no main effects of languages spoken, number of books in the household, school quality, age, gender, parental SES, current exposure to violence, reading ability, the degree to which participants report ruminating on the violence they witnessed, the degree to which the violence was mainly encountered in the home or neighborhood, social support, self-esteem, or exposure to violence in childhood, all $p > 0.05$. There were no interactions with feedback type and age, gender, stress, reading ability, the degree to which participants report ruminating on the violence they witnessed, the degree to which the violence was mainly encountered in the home or neighborhood, or self-esteem, all $p > 0.05$ (see Table 8).

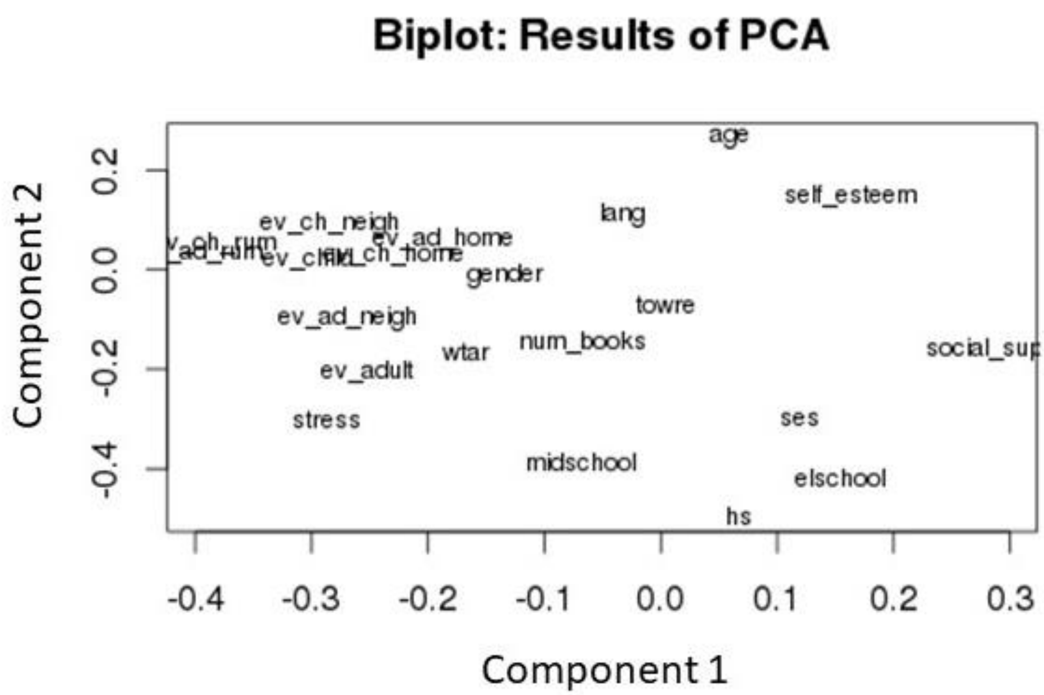
Finally, a post-hoc correlation was run to determine whether reward ratings predicted accuracy. There was no significant correlation between reward ratings and accuracy when collapsing across the three feedback conditions, $r(175) = -0.01$, $p = 0.88$.

However, when tested separately, there was a significant correlation between reward ratings of Content, $r(58) = -0.27$, $p = 0.03$, but not Elaborative, $r(56) = 0.03$, $p = 0.83$, and Positive Feedback, $r(57) = 0.2$, $p = 0.13$. However, although the individual correlation was significant at $p < 0.05$, when corrected for multiple comparisons, the effect does not hold, $p = 0.10$. Additionally, these analyses did not take into account feedback accuracy. When taking into account feedback accuracy, none of the correlations between reward and accuracy, in any of the three feedback conditions, were significant, $p > 0.05$.

3.4.3 Principal Components Analysis

To examine the relationship among the factors tested, and to determine whether it would be useful to conduct a follow-up analysis using components rather than individual factors, a Principal Components Analysis with varimax rotation was conducted. The scree plot showed a clear break point after the first component, although several components had eigenvalues greater than 1. When components were examined for meaningfulness among the factors, only the first component was interpretable, with several factors related to exposure to violence scoring high. Since the goal of the study was to isolate the effects of exposure to violence, rather than examine several factors relating to exposure to violence, we chose not to reanalyze the data by grouping these factors. Additionally, since other components were difficult to interpret due to the relation between factors being unapparent, and were after the break in the screen plot, no other factors were combined for an additional analysis. The biplot, however, provides a visual demonstration of the relationship among the factors, and thus is included below for descriptive purposes. Specifically, childhood and current exposure to violence in the home are closely related;

rumination of childhood and current violent events are very close. Generally, current and childhood (ev_child) exposure to violence, rumination on violent events, and the degree to which violence was encountered in the home and neighborhood, are all closely related. Also close to factors related to violence is perceived stress (stress). Verbal IQ is close to number of books, and number of books is close to reading ability. Social support is strikingly on the opposite side of the biplot compared to exposure to violence. Elementary, middle, and high school quality are close, and SES is particularly close to elementary school quality.



3.5 Discussion

3.5.1 Performance results

Contrary to the results of Study 1, accuracy for nonword reading aloud did not significantly differ by feedback type with which pseudowords were trained. This discrepancy may be due to minor differences in study design, as well as including one syllable words, since the pattern of results for two syllable words more closely resembles that of the previous study, where pseudowords trained with EF were read aloud with higher accuracy than pseudowords trained with CF and PF. Other potential sources of differences in results include the initial training session involved in this study, which may have provoked a greater reliance on orthography-phonology learning strategy relative to feedback.

3.5.2 Interaction with exposure to violence

In Model 1b, increasing levels of exposure to violence predicted numerically higher accuracy for nonwords trained with EF compared to CF, yet the effect was not significant. This may suggest that individuals exposed to high levels of violence do not benefit more from rewarding feedback. However, it may also be due to deficiencies in the study design. For example, the task relies on nonword reading ability, and thus, the interaction of exposure to violence with feedback type may be confounded by individual reading ability. In our sample, there was a great amount of variation in nonword reading ability, with scores on TOWRE ranging from 15 to 65. There was also more variability in testing accuracy among participants whose TOWRE scores were below than above the median TOWRE score (median = 49), $F(32,38) = 0.297$, $p < 0.001$. Further, the pseudowords varied in regularity to typical English orthography-phonology mappings, thereby adding additional noise to the data. Thus, it is possible that lower reading ability introduced a source of noise, which reduced power to detect a true effect.

Given the likely influence of reading ability, the model was updated to include the interaction of exposure to violence, reading ability, and feedback (Model 1c). In this model, the interaction of exposure to violence and feedback was significant, but in the reverse direction. Specifically, higher levels of exposure to violence interacted with feedback type, with higher accuracy for pseudowords trained with CF, compared to EF. This again, could be due to deficiencies in the study design; or, could suggest that high exposure to violence, after taking out variance associated with both high exposure to violence and high reading ability, does predict lower accuracy for items trained with the more rewarding (EF) compared to content informative (CF) feedback. Another possibility is that individuals with lower reading ability do in fact rely on more content-informative, instructional type of feedback, rather than rewarding feedback; however, it is not clear why this effect would be stronger for higher levels of exposure to violence.

However, the results of this model also showed that high reading ability and high exposure to violence interacted with feedback type, with a greater benefit for EF compared to CF. This may be due to the rewarding element, plus the content included in EF. High reading ability may rely on content, while high exposure to violence may moderate effectiveness of the reward component. It is also consistent with research showing that minority students who had high compared to low levels of mistrust had a greater benefit from constructive feedback that communicated high expectations of the student and belief in their potential (Yeager et al., 2014). The authors of this study highlight the importance of trust, which can undermine students' perceptions of critical feedback. A similar mechanism may explain the results of the current study. Participants who were exposed to high levels of violence may have decreased trust, leading them to dismiss content-informative feedback that does communicate their correct application of the target skill (CF).

This is also consistent with previous literature showing that stress reduces the use of negative feedback (Petzold et al., 2010). In the current study, although we did not test negative feedback, we tested Content Feedback which did not include a reward component. Content Feedback was rated as less rewarding than Elaborative and Positive Feedback, and thus may be considered “negatively valenced.” Individuals who experienced high exposure to violence may, like stressed individuals, use negatively valenced feedback less. They may, for example, be more sensitive to the negative valence, and thus have fewer mental resources available for learning in a negatively valenced feedback condition.

Other previous literature demonstrates increased neural activity during reward anticipation (Kumar, Kishore, & Gupta, 2012) among stressed individuals. It is possible that increased neural activity in anticipation of a reward may extend to increased neural activity in anticipation of positive feedback. Our study provides evidence that individuals exposed to high levels of violence, with high reading ability, learned the pronunciations of pseudowords trained with positive, informative feedback, better than feedback that was merely informative, but not positive. If replicated, this finding has potential to expand previous understanding of stress and reward processing to include feedback learning.

The null effects of other variables included in the model further help clarify the results. Neither stress, SES, self-esteem, social support, school quality, current exposure to violence, rumination on violent events, the degree to which the violence reported was in the home, nor the degree of neighborhood violence exposure affected accuracy or interacted with feedback type to predict accuracy. These null results suggest that the effects of exposure to violence in childhood are unlikely to be due to these other potentially related factors.

3.5.3 Subjective ratings

Consistent with predictions, both elaborative and positive feedback were rated as more rewarding than CF, thus replicating the main effects reported in Study 1. This is unsurprising, since EF and PF both provide performance feedback, shown to be rewarding (Hattie & Timperley, 2007).

The results of Model 2b demonstrate that higher levels of childhood violence predicted higher subjective reward ratings of Elaborative and Positive compared to Content Feedback. This aligns with previous research showing stress-induced increases in reactivity to negatively valenced stimuli (Tottenham et al., 2011; Treadway et al., 2013), such as threatening faces (van Marle et al., 2009) and social exclusion (Gonzalez, Beckes, Wagner, & Heatherton, 2012).

These results would seemingly align with studies showing heightened reward approach behavior demonstrated among stressed individuals (Treadway et al., 2013). However, the results show a significant reduction in reward ratings for CF for high levels of violence; not an increase in reward ratings for EF and PF for high levels of violence. Thus, more research is needed to determine whether there are differences in the degree to which individuals exposed to high levels of violence subjectively perceive rewarding stimuli.

The effects of the other variables included in the model further clarify our results by demonstrating the possible effects of other related factors on reward ratings. Interestingly, stress had a marginally significant main effect on reward ratings, with higher levels of stress predicting lower overall ratings. This was distinct from exposure to violence, which predicted lower reward ratings only for the negatively valenced feedback condition. This calls for further research to identify the effects of different types of stress.

Higher parental SES predicted higher reward ratings for EF and PF, both compared to CF. This was surprising, but overall, importantly suggests that the effects of exposure to violence and SES are non-overlapping; and that, although low SES and exposure to violence commonly co-occur, their effects on feedback processing are distinct.

Higher current exposure to violence predicted lower reward ratings for PF compared to CF. This was somewhat surprising, given that the direction was the reverse as the effect of exposure to violence in childhood. However, the effect was only significant for PF, which included only a reward, but no content information. Previous research demonstrates that African-American, but not white, students perceived general, positive feedback as conveying low expectations (Lawrence, Crocker, & Blanton, 2011). Another study demonstrated that African-American students who were asked to disclose their race, and who were high, compared to low, in race-based rejection sensitivity, did not benefit from general, positive feedback (Mendoza-Denton, Goldman-Flythe, Pietrzak, Downey, & Aceves, 2010). Although these studies specifically tested stigmatized populations, it is possible that a similar mechanism, such as frequent exposure to threat (for minority students, stereotype threat; for individuals exposed to high levels of violence, threat of violent events) explains the reduced reward ratings for general, positive feedback, among individuals reporting exposure to high levels of violence in the past year. It may be that mistrust among learners leads to poor reception of general, positive feedback; but, that when specific information about the learner's successful application of a target skill is provided (EF), learners' trust increases and they perceive the feedback as valid, thereby benefiting from it.

Number of books marginally predicted lower overall ratings of reward across all feedback types. This suggests that number of books in the household may relate to subjective value of reading, with fewer books in the home predicting lower reward ratings on feedback specific to a pseudoword reading task.

Also interesting was the observation that social support marginally significantly interacted with feedback condition on reward ratings. In contrast to exposure to violence, higher levels of social support predicted higher reward ratings for CF compared to EF and PF. This is in line with previous research showing that social supports reduces perception of threat (Cohen & McKay, 1984; Harber et al., 2011; Schnall et al., 2008). Together, these findings may suggest that social support buffers against a more negative perception of content-based feedback that does not include a reward component, while exposure to violence sensitizes an individual to the negative valence of this feedback type.

We find no evidence of an interaction of feedback type on reward ratings with the degree to which participants ruminate on the violent events, suggesting that it may be exposure itself, rather than ruminating on the events, which alters reward and threat processing. There is also no evidence of an interaction with the degree to which reported violence was in the home or neighborhood, suggesting that violence exposure in both the home and neighborhood may contribute to differential reward ratings.

3.5.4 Limitations

CF (e.g. "It's best to blend po-tep") may be perceived as ambiguous. Although participants are told that all three feedback types indicate a correct answer, CF may be perceived as corrective, thereby implicitly suggesting the given answer was somehow sub-optimal. However, rather than alter the design implemented in Study 1, we chose to keep the design consistent for facilitate direct comparisons across studies. To address the ambiguity of CF, a negative feedback condition, where feedback is presented on incorrect trials, could be compared to positive feedback. This option was not pursued in the current work because presenting feedback on incorrect as well as correct trials would create an additional confound, with differences not only in feedback type but also in response accuracy. However, it is an avenue of future research, further discussed below. To mitigate concerns about the ambiguity of CF in our study, we probed participants' perceptions of CF in a debriefing session. Sixty-three out of the 79 participants (nearly 80%) reported that they thought CF indicated an incorrect answer. A subsequent analysis was conducted to try to determine what participant characteristics corresponded to whether they reported thinking that CF indicated a correct compared to an incorrect answer. Interestingly, only exposure to violence in childhood (not languages spoken, number of books, school quality, age, gender, parental SES, current exposure to violence, stress, reading ability, rumination of violence, exposure to violence in home vs. neighborhood, social support, or self-esteem, all $p > 0.05$) significantly predicted whether participants thought CF indicated a correct or incorrect answer, B = -0.01, t(77) = -2.12, p < 0.05 (Figure 13). Increasing levels of exposure to violence in childhood predicted decreased likelihood of thinking that CF indicated a correct answer, even though every participant was explicitly told in the beginning of the study that CF did in fact indicate a correct answer. This could be viewed as a limitation, where this effect explains the differential reward ratings. However, it also could be viewed as supporting our findings, with high exposure to violence in childhood relating to increased sensitivity to negatively valenced stimuli.

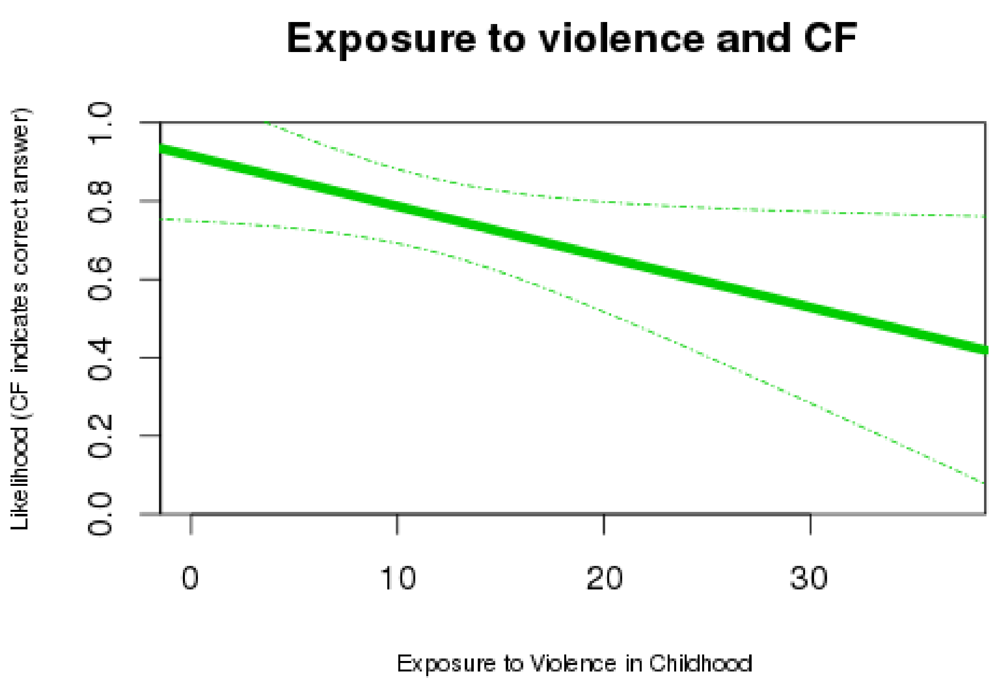


Figure 13: Increasing levels of exposure to violence result in decreased likelihood of indicating that participant thought that Content Feedback (CF, green, consistent with previous color scheme for feedback types) indicated a correct answer. The dotted lines

represent the 95% confidence interval.

Finally, although the study attempts to control for factors that commonly coincide with childhood exposure to violence, including SES and perceived stress, there are multiple other factors that may correlate with exposure to violence, as discussed in the *Limitations* section of Study 2. Additional potential confounds relate to possible sources of inaccurate self-report, including memory biases, demand-characteristics, and social desirability. Therefore, this study offers evidence that exposure to violence is a moderator of feedback effects, yet replication and expansion of these results awaits future studies than can more directly test for links between feedback response and exposure to violence. Further, our measure asked participants to report exposure to violence during the ages of 3 to 16. This is a wide age range which spans multiple stages of development, and thus no conclusions can be drawn regarding the timing of the exposure to violence. Future studies could attempt to determine whether the effects of exposure to violence differ by the timing of exposure.

CONCLUDING REMARKS

Significance

Given the low performance of urban schools, especially in the area of literacy, as well as the long-term consequences of poor reading skills, it is essential to investigate practices that attenuate such impairments and enhance literacy instruction for these students. Feedback, in particular, has the potential to increase the reward value of applying a particular skill by engaging both reward and task-relevant regions (Study 1). Paired with orthography-phonology mapping, elaborative feedback may improve literacy skills, thereby improving overall outcome especially for students in urban districts.

The relevance of Elaborative Feedback, found to be effective due to concurrent activation of reward and task-relevant regions (Study 1), for individuals exposed to urban stressors was tested in Study 3. In Study 3, the same feedback paradigm from Study 1 was used in a behavioral study that examined individual differences. Among the several variables tested, exposure to violence significantly moderated subjective ratings of feedback, with higher exposure to childhood violence predicting higher ratings for Elaborative and Positive compared to Content feedback. In another analysis on accuracy, elaborative feedback interacted with reading ability and feedback, with higher exposure to violence and higher reading ability predicting increased accuracy for nonwords trained with Elaborative compared to Content feedback. Together, these findings suggest that Elaborative Feedback, introduced in Study 1, may be particularly important for individuals exposed to high levels of violence (Study 3).

Study 2 offers evidence of a potential neural basis for these differences. Specifically, in Study 2, we have shown evidence for differences in neural connectivity by degree of exposure to violence in childhood among regions known to relate to affect regulation and working memory (Study 2). These results suggest that the effects of violence exposure in childhood, even when controlling for SES, persist at least into early adulthood. Such differences in connectivity call for specially designed interventions that capitalize on these differences.

Further, decreased effective connectivity from vmPFC to the left amygdala during a more negatively valenced feedback condition (Content Feedback), among individuals exposed to high levels of violence (Study 2), suggests decreased regulation of the amygdala's response to negatively valenced stimuli (Silvers et al., 2017; Urry et al., 2006). This aligns with decreased accuracy in Study 3 for the high reading ability and high exposure to violence group when reading aloud pseudowords trained with Content Feedback, relative to Elaborative and Positive Feedback (both of which contained a reward component). Decreased vmPFC-amygdala connectivity also aligns with differential reward ratings by exposure to violence, where exposure to violence predicted decreased reward ratings for Content compared to Elaborative and Positive Feedback (Study 3). Overall, the results suggest that individuals reporting high exposure to violence show reduced regulation of the amygdala and the affective response, and reduced learning in response to negatively valenced feedback.

Decreased connectivity between right dlPFC and mid-cingulate for individuals exposed to high levels of violence (Study 2) may further support this conclusion. The mid-cingulate has been shown to correspond to behavioral interference effects from negatively valenced stimuli (Brown & Jones, 2008; Pereira et al., 2010). It is possible that decreased connectivity between the dlPFC and mid-cingulate would correspond to learning deficits in emotionally negative contexts. If so, this would support the conclusion that individuals exposed to high levels of violence would show reduced learning in more negatively valenced feedback conditions (Study 3). However, further research is needed to investigate this.

Along these lines, previous studies have demonstrated stress-related deficits in maintaining goal-directed behavior when negatively valenced distractor images are present (Malter Cohen et al., 2013; Tottenham et al., 2010). And, that rewarding stimuli can buffer against interference effects from negatively valenced distractor images (Padmala et al., 2017; Yokoyama et al., 2015). Based on the results of Study 3, it is possible that positive but not negative feedback serves to buffer against interference effects of previously experienced violent-related stimuli, thus buffering against interference effects and improving learning for these individuals.

Decreased connectivity between the right dlPFC and IPS and MFG (Study 2) is in line with previous research showing stress-induced working memory impairments. Since negative feedback (as provided on incorrect trials) has been shown to recruit working memory processes, it is possible that individuals exposed to high levels of violence would benefit more from positive compared to negative feedback. Although we did not test negative feedback, the results of Studies 1, 2, and 3 provide a basis on which to test the effectiveness of positive, informative feedback (Elaborative Feedback) compared to negative feedback, for individuals exposed to high levels of violence. Further research could examine differential effectiveness and subjective reward ratings of positive, compared to negative feedback. This is discussed further in the following section.

Future directions

The research outlined here can be expanded upon with potential follow-up studies examining differential subjective reward ratings for a variety of stimuli, by exposure to violence. For example, social rewards, such as successful communication, as well as extrinsic rewards such as food and money could be used to better characterize alterations in reward processing (also, reward approach compared to consumption) due to exposure to violence. A study using a 2 x 2 factorial design could manipulate exposure to a stressor and reward value of subsequent stimuli, thereby controlling for confounding factors and enabling identification of a causal relationship between stress and reward processing. Finally, additional studies could test whether differential reward ratings translate into performance benefits, for example, on a probabilistic feedback learning task. Using a probabilistic learning task would also minimize domain-specific effects, potentially isolating the effects of feedback.

Interference effects of negatively valenced stimuli could also be further explored for individuals exposed to violence and/or other urban stressors. The neural mechanism for such interference effects could be further explored by examining task-based functional as well as structural connectivity. Additionally, studies can test whether reward-based instruction buffers against these interference effects.

Finally, it would be useful to test the effectiveness of positive compared to negative feedback for individuals exposed to high levels of violence. While Study 1 and Study 3 examined Content Feedback, which did not include a reward component, neither study examined feedback provided on incorrect trials (negative feedback). Since negative feedback has been shown to recruit working memory processes, and the results of Study 2 show decreased connectivity among working memory neural regions, we predict that individuals exposed to high levels of violence would benefit less from negative, compared to positive, feedback. Negative feedback, however, is not necessarily negatively valenced. This distinction would allow the valence of the negative feedback to be manipulated as well. The results of Study 2 show decreased regulation of the amygdala by the vmPFC in the more negatively valenced feedback condition; therefore, we predict that higher exposure to violence would correspond to decreased reward ratings and decreased performance benefits from more threatening negative feedback.

Conclusion

Overall, this dissertation work provides initial support for the integration of positively valenced affective interventions with academic instruction, especially among communities where students are exposed to high levels of stressors. Further, the evidence provided here brings us one step closer to understanding what kinds of feedback may be most beneficial for this particularly at-risk population. Moreover, this work provides evidence that a particular stressor associated with low SES, exposure to violence, exerts effects that can be distinguished from those of low SES, thereby opening up future avenues for targeted intervention.

References

Aikens, N. L., & Barbarin, O. (2008). Socioeconomic differences in reading trajectories: The contribution of family, neighborhood, and school contexts. *Journal of Educational Psychology*, *100*(2), 235.

Alexander, M. P., Fischer, R. S., & Friedman, R. (1992). Lesion Localization in Apractic Agraphia. *Archives of Neurology*, *49*(3), 246–251. https://doi.org/10.1001/archneur.1992.00530270060019

Anderson, T. W., & Darling, D. A. (1952). Asymptotic theory of certain “goodness of-fit” criteria based on stochastic processes. *Annals of Mathematical Statistics*.

Arnett, J. J., & Jensen, J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist*, *55*(5), 469–480. https://doi.org/10.1037/0003-066X.55.5.469

Arnsten, A. F. T. (2009). Stress signalling pathways that impair prefrontal cortex structure and function. *Nature Reviews Neuroscience*. https://doi.org/10.1038/nrn2648

Arnsten, A. F. T., Wang, M. J., & Paspalas, C. D. (2012). Neuromodulation of Thought: Flexibilities and Vulnerabilities in Prefrontal Cortical Network Synapses. *Neuron*. https://doi.org/10.1016/j.neuron.2012.08.038

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*. https://doi.org/10.1016/j.jml.2007.12.005

Banks, S. J., Eddy, K. T., Angstadt, M., Nathan, P. J., & Phan, K. L. (2007). Amygdala–frontal connectivity during emotion regulation. *Social Cognitive and Affective Neuroscience*, *2*(4), 303–312. https://doi.org/10.1093/scan/nsm029

Barbarin, O., Bryant, D., McCandies, T., Burchinal, M., Early, D., Clifford, R., … Howes, C. (2006). Children enrolled in public pre-K: The relation of family life, neighborhood quality, and socioeconomic resources to early competence. *American Journal of Orthopsychiatry*, *76*(2), 265–276. https://doi.org/10.1037/0002-9432.76.2.265

Barbey, A. K., Koenigs, M., & Grafman, J. (2013). Dorsolateral prefrontal contributions to human working memory. *Cortex*, *49*(5), 1195–1205. https://doi.org/10.1016/j.cortex.2012.05.022

Bernichon, T., Cook, K. E., & Brown, J. D. (2003). Seeking self-evaulative feedback: The interactive role of global self-esteem and specific self-views. *Journal of Personality and Social Psychology*, *84*(1), 194.

Bhattacharya, A., & Ehri, L. C. (2004). Read and Spell Words. *Journal of Learning Disabilities*, *37*(4), 331–348. https://doi.org/10.1177/00222194040370040501

Bickel, W. K., Moody, L., Quisenberry, A. J., Ramey, C. T., & Sheffer, C. E. (2014). A Competing Neurobehavioral Decision Systems model of SES-related health and behavioral disparities. *Preventive Medicine*, *68*, 37–43. https://doi.org/10.1016/j.ypmed.2014.06.032

Binder, J. R., Medler, D. A., Desai, R., Conant, L. L., & Liebenthal, E. (2005). Some neurophysiological constraints on models of word naming. *NeuroImage*, *27*(3), 677–693. https://doi.org/10.1016/j.neuroimage.2005.04.029

Binder, J. R., Medler, D. a, Westbury, C. F., Liebenthal, E., & Buchanan, L. (2006). Tuning of the human left fusiform gyrus to sublexical orthographic structure.

NeuroImage, *33*(2), 739–748. https://doi.org/10.1016/j.neuroimage.2006.06.053
Binder, J. R., & Mohr, J. P. (1992). The topography of callosal reading pathways. *Brain*, *115*(6), 1807–1826. https://doi.org/10.1093/brain/115.6.1807
Biswal, B., Zerrin Yetkin, F., Haughton, V. M., & Hyde, J. S. (1995). Functional connectivity in the motor cortex of resting human brain using echo-planar mri. *Magnetic Resonance in Medicine*, *34*(4), 537–541. https://doi.org/10.1002/mrm.1910340409
Blair, K., Marsh, A. A., Morton, J., Vythilingam, M., Jones, M., Mondillo, K., … Blair, J. R. (2006). Choosing the lesser of two evils, the better of two goods: specifying the roles of ventromedial prefrontal cortex and dorsal anterior cingulate in object choice. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *26*(44), 11379–11386. https://doi.org/10.1523/JNEUROSCI.1640-06.2006
Blomert, L. (2011). The neural signature of orthographic-phonological binding in successful and failing reading development. *NeuroImage*, *57*(3), 695–703. https://doi.org/10.1016/j.neuroimage.2010.11.003
Boyes, M. E., Hasking, P. A., & Martin, G. (2016). Adverse Life Experience and Psychological Distress in Adolescence: Moderating and Mediating Effects of Emotion Regulation and Rumination. *Stress and Health*, *32*(4), 402–410. https://doi.org/10.1002/smi.2635
Brinko, T. (1993). The Practice of Giving Feedback to Improve Teaching. *The Journal of Higher Education*, *64*(5), 574–593.
Brown, C. A., & Jones, A. K. (2008). A role for midcingulate cortex in the interruptive effects of pain anticipation on attention. *Clinical Neurophysiology : Official Journal of the International Federation of Clinical Neurophysiology*, *119*(10), 2370–2379. https://doi.org/10.1016/j.clinph.2008.06.014
Buchsbaum, B. R., Baldo, J., Okada, K., Berman, K. F., Dronkers, N., D'Esposito, M., & Hickok, G. (2011). Conduction aphasia, sensory-motor integration, and phonological short-term memory – An aggregate analysis of lesion and fMRI data. *Brain and Language*, *119*(3), 119–128. https://doi.org/10.1016/j.bandl.2010.12.001
Buckner, R. L., Andrews-Hanna, J. R., & Schacter, D. L. (2008). The Brain's Default Network: Anatomy, Function, and Relevance to Disease. *Annals of the New York Academy of Sciences*, *1124*(1), 1–38. https://doi.org/10.1196/annals.1440.011
Burdick-will, J., Ludwig, J., Raudenbush, S. W., Sampson, R. J., & Sharkey, P. (2010). Converging Evidence for Neighborhood Effects on Children's Test Scores: An Experimental, Quasi-Experimental, and Observational Comparison, 1–53.
Cahill, L., Haier, R. J., Fallon, J., Alkire, M. T., Tang, C., Keator, D., … McGaugh, J. L. (1996). Amygdala activity at encoding correlated with long-term, free recall of emotional information. *Proceedings of the National Academy of Sciences*. https://doi.org/10.1073/pnas.93.15.8016
Cain, K., & Oakhill, J. (2007). *Children's comprehension problems in oral and written language : a cognitive perspective*. Guilford Press.
Cartwright, K. B., Marshall, T. R., & Wray, E. (2016). A Longitudinal Study of the Role of Reading Motivation in Primary Students' Reading Comprehension: Implications for a Less Simple View of Reading. *Reading Psychology*. https://doi.org/10.1080/02702711.2014.991481
Cauffman, E., Shulman, E. P., Steinberg, L., Claus, E., Banich, M. T., Graham, S., &

Woolard, J. (2010). Age differences in affective decision making as indexed by performance on the Iowa Gambling Task. *Developmental Psychology*, *46*(1), 193–207. https://doi.org/10.1037/a0016128

Clark, C., Ryan, L., Kawachi, I., Canner, M. J., Berkman, L., & Wright, R. J. (2008). Witnessing community violence in residential neighborhoods: a mental health hazard for urban women. *Journal of Urban Health : Bulletin of the New York Academy of Medicine*, *85*(1), 22–38. https://doi.org/10.1007/s11524-007-9229-8

Cohen, J. (1960). Kappa: coefficient of concordance. *Educ. Psych. Measurement*, *20*(37).

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A Global Measure of Perceived Stress on JSTOR. *Journal of Health and Social Behavior*, *24*(4), 385–396. Retrieved from http://www.jstor.org.proxy.libraries.rutgers.edu/stable/2136404?seq=1#page_scan_tab_contents

Cohen, S., & McKay, G. (1984). Social support, stress and the buffering hypothesis: A theoretical analysis. *Handbook of Psychology and Health*, *4*, 253–267.

Cook, F., Ciorciari, J., Varker, T., & Devillya, G. J. (2009). Changes in long term neural connectivity following psychological trauma. *Clinical Neurophysiology*, *120*(2), 309–314. https://doi.org/10.1016/J.CLINPH.2008.11.021

Cox, R. W. (1996). AFNI: software for analysis and visualization of functional magnetic resonance neuroimages. *Computers and Biomedical Research, an International Journal*, *29*(3), 162–173. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8812068

D'Argembeau, A. (2013). *On the role of the ventromedial prefrontal cortex in self-processing: the valuation hypothesis.* Frontiers E-books. Retrieved from https://books.google.com/books?hl=en&lr=&id=RpQgBQAAQBAJ&pgis=1

Damasio, A. R., & Damasio, H. (1983). The anatomic basis of pure alexia. *Neurology*, *33*(12), 1573–1583. https://doi.org/10.1212/WNL.33.12.1573

Damoiseaux, J. S., & Greicius, M. D. (2009). Greater than the sum of its parts: a review of studies combining structural connectivity and resting-state functional connectivity. *Brain Structure & Function*, *213*(6), 525–533. https://doi.org/10.1007/s00429-009-0208-6

De Bellis, M. D., Hooper, S. R., Spratt, E. G., & WOOLLEY, D. P. (2009). Neuropsychological findings in childhood neglect and their relationships to pediatric PTSD. *Journal of the International Neuropsychological Society*, *15*(6), 868–878. https://doi.org/10.1017/S1355617709990464

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, *125*(6), 627-668-700. https://doi.org/10.1037/0033-2909.125.6.627

Dehaene, S., & Cohen, L. (2011). The unique role of the visual word form area in reading. *Trends in Cognitive Sciences*, *15*(6), 254–262. https://doi.org/http://dx.doi.org.proxy.libraries.rutgers.edu/10.1016/j.tics.2011.04.003

Delgado, M. R., Nystrom, L. E., Fissell, C., Noll, D. C., & Fiez, J. a. (2000). Tracking the hemodynamic responses to reward and punishment in the striatum. *Journal of Neurophysiology*, *84*, 3072–3077.

Demir-Lira, Ö. E., Voss, J. L., O'Neil, J. T., Briggs-Gowan, M. J., Wakschlag, L. S., & Booth, J. . (2016). Early-life stress exposure associated with altered prefrontal resting-state fMRI connectivity in young children. *Developmental Cognitive Neuroscience*, *19*, 107–114. https://doi.org/10.1016/J.DCN.2016.02.003

Diakidoy, I. A. N., Stylianou, P., Karefillidou, C., & Papageorgiou, P. (2005). The relationship between listening and reading comprehension of different types of text at increasing grade levels. *Reading Psychology*. https://doi.org/10.1080/02702710590910584

Dillon, D. G., Holmes, A. J., Birk, J. L., Brooks, N., Lyons-Ruth, K., & Pizzagalli, D. A. (2009). Childhood Adversity Is Associated with Left Basal Ganglia Dysfunction During Reward Anticipation in Adulthood. *Biological Psychiatry*, *66*(3), 206–213. https://doi.org/10.1016/J.BIOPSYCH.2009.02.019

Dweck, C. S. (1975). The role of expectations and attributions in the alleviation of learned helplessness. *Journal of Personality and Social Psychology*, *31*(4), 674–685.

Dweck, C. S., & Bempechat, J. (1983). Children's theories of intelligence: Consequences for learning. *Learning and Motivation in the Classroom*, 239–256.

Eden, G. F., Jones, K. M., Cappell, K., Gareau, L., Wood, F. B., Zeffiro, T. A., … Flowers, D. L. (2004). Neural changes following remediation in adult developmental dyslexia. *Neuron*, *44*(3), 411–422. https://doi.org/10.1016/j.neuron.2004.10.019

Ehri, L. C., Nunes, S. R., Stahl, S. a., & Willows, D. M. (2001). Systematic Phonics Instruction Helps Students Learn to Read: Evidence from the National Reading Panel's Meta-Analysis. *Review of Educational Research*, *71*(3), 393–447. https://doi.org/10.3102/00346543071003393

Ehri, L. C., Satlow, E., & Gaskins, I. (2009). Grapho-Phonemic Enrichment Strengthens Keyword Analogy Instruction for Struggling Young Readers. *Reading & Writing Quarterly*, *25*(2–3), 162–191. https://doi.org/10.1080/10573560802683549

Eklund, A., Nichols, T. E., & Knutsson, H. (2016). Cluster failure: Why fMRI inferences for spatial extent have inflated false-positive rates. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(28), 7900–7905. https://doi.org/10.1073/pnas.1602413113

Eluvathingal, T. J., Chugani, H. T., Behen, M. E., Juhász, C., Muzik, O., Maqbool, M., … Makki, M. (2006). Abnormal brain connectivity in children after early severe socioemotional deprivation: a diffusion tensor imaging study. *Pediatrics*, *117*(6), 2093–2100. https://doi.org/10.1542/peds.2005-1727

Evans, G. W., & Kim, P. (2010). Multiple risk exposure as a potential explanatory mechanism for the socioeconomic status-health gradient. *Annals of the New York Academy of Sciences*, *1186*, 174–189. https://doi.org/10.1111/j.1749-6632.2009.05336.x

Fan, Y., Pestke, K., Feeser, M., Aust, S., Pruessner, J. C., Böker, H., … Grimm, S. (2015). Amygdala-Hippocampal Connectivity Changes During Acute Psychosocial Stress: Joint Effect of Early Life Stress and Oxytocin. *Neuropsychopharmacology : Official Publication of the American College of Neuropsychopharmacology*, *40*(12), 2736–2744. https://doi.org/10.1038/npp.2015.123

Farah, M. J., Shera, D. M., Savage, J. H., Betancourt, L., Giannetta, J. M., Brodsky, N. L., … Hurt, H. (2006). Childhood poverty: specific associations with neurocognitive development. *Brain Research*, *1110*(1), 166–174. https://doi.org/10.1016/j.brainres.2006.06.072

Fields, R. D. (2010). Neuroscience. Change in the brain's white matter. *Science (New*

York, N.Y.), *330*(6005), 768–769. https://doi.org/10.1126/science.1199139
Fiez, J. A., Balota, D. A., Raichle, M. E., & Petersen, S. E. (1999). Effects of Lexicality, Frequency, and Spelling-to-Sound Consistency on the Functional Anatomy of Reading. *Neuron*, *24*(1), 205–218. https://doi.org/10.1016/S0896-6273(00)80833-8
Foster, H., & Brooks-Gunn, J. (2009). Toward a Stress Process Model of Children's Exposure to Physical Family and Community Violence. *Clinical Child and Family Psychology Review*, *12*(2), 71–94. https://doi.org/10.1007/s10567-009-0049-0
Fox, M. D., & Raichle, M. E. (2007). Spontaneous fluctuations in brain activity observed with functional magnetic resonance imaging. *Nat Rev Neurosci*, *8*(9), 700–711. https://doi.org/nrn2201 [pii]\n10.1038/nrn2201
Fox, M. D., Snyder, A. Z., Vincent, J. L., Corbetta, M., Van Essen, D. C., & Raichle, M. E. (2005). The human brain is intrinsically organized into dynamic, anticorrelated functional networks. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(27), 9673–9678. https://doi.org/10.1073/pnas.0504136102
Friston, K. J. (1994). Functional and effective connectivity in neuroimaging: A Synthesis. *Human Brain Mapping.*, *2*(1–2), 56–78. Retrieved from http://cream.fil.ion.ucl.ac.uk/~karl/Functional and effective connectivity in neuroimaging.pdf
Gabrieli, J. D. E. (2009). Dyslexia: a new synergy between education and cognitive neuroscience. *Science (New York, N.Y.)*, *325*(5938), 280–283. https://doi.org/10.1126/science.1171999
Gallo, L. C., Bogart, L. M., Vranceanu, A.-M., & Matthews, K. A. (2005). Socioeconomic Status, Resources, Psychological Experiences, and Emotional Responses: A Test of the Reserve Capacity Model. *Journal of Personality and Social Psychology*, *88*(2), 386–399. https://doi.org/10.1037/0022-3514.88.2.386
Gee, D. G., Gabard-Durnam, L. J., Flannery, J., Goff, B., Humphreys, K. L., Telzer, E. H., … Tottenham, N. (2013). Early developmental emergence of human amygdala-prefrontal connectivity after maternal deprivation. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(39), 15638–15643. https://doi.org/10.1073/pnas.1307893110
Gianaros, P. J., Horenstein, J. A., Hariri, A. R., Sheu, L. K., Manuck, S. B., Matthews, K. A., & Cohen, S. (2008). Potential neural embedding of parental social standing. *Social Cognitive and Affective Neuroscience*, *3*(2), 91–96. https://doi.org/10.1093/scan/nsn003
Gillespie, C. F., Bradley, B., Mercer, K., Smith, A. K., Conneely, K., Gapen, M., … Ressler, K. J. (2009). Trauma exposure and stress-related disorders in inner city primary care patients. *General Hospital Psychiatry*, *31*(6), 505–514. https://doi.org/10.1016/J.GENHOSPPSYCH.2009.05.003
Goff, D. A., Pratt, C., & Ong, B. (2005). The relations between children's reading comprehension, working memory, language skills and components of reading decoding in a normal sample. *Reading and Writing*. https://doi.org/10.1007/s11145-004-7109-0
Gonzalez, M. Z., Beckes, L., Wagner, D. D., & Heatherton, T. F. (2012). *Adolescent neighborhood quality predicts adult dACC response to social exclusion*.
Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education (RASE).*

Graves, W. W., Boukrina, O., Mattheiss, S. R., Alexander, E. J., & Baillet, S. (2017). Reversing the standard neural signature of the word-nonword distinction in lexical decision: A multimodal neuroimaging study. *Journal of Cognitive Neuroscience*, *29*(1), 3–6. https://doi.org/10.1111/j.1540-8191.2009.00972.x

Graves, W. W., Desai, R., Humphries, C., Seidenberg, M. S., & Binder, J. R. (2010). Neural Systems for Reading Aloud: A Multiparametric Approach. *Cerebral Cortex*, *20*(8), 1799–1815. https://doi.org/10.1093/cercor/bhp245

Graves, W. W., Grabowski, T. J., Mehta, S., & Gordon, J. K. (2007). A neural signature of phonological access: distinguishing the effects of word frequency from familiarity and length in overt picture naming. *Journal of Cognitive Neuroscience*, *19*(4), 617–631. https://doi.org/10.1162/jocn.2007.19.4.617

Graves, W. W., Grabowski, T. J., Mehta, S., & Gupta, P. (2008). The left posterior superior temporal gyrus participates specifically in accessing lexical phonology. *Journal of Cognitive Neuroscience*, *20*(9), 1698–1710. https://doi.org/10.1162/jocn.2008.20113

Gupta, P., Lipinski, J., Abbs, B., Lin, P.-H., Aktunc, E., Ludden, D., … Newman, R. (2004). Space aliens and nonwords: stimuli for investigating the learning of novel word-meaning pairs. *Behavior Research Methods, Instruments, & Computers : A Journal of the Psychonomic Society, Inc*, *36*(4), 599–603. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15641405

Gusnard, D. a, Raichle, M. E., & Raichle, M. E. (2001). Searching for a baseline: functional imaging and the resting human brain. *Nature Reviews. Neuroscience*, *2*(10), 685–694. https://doi.org/10.1038/35094500

Hackman, D. A., & Farah, M. J. (2009). Socioeconomic status and the developing brain. *Trends in Cognitive Sciences*, *13*(2), 65–73. https://doi.org/10.1016/j.tics.2008.11.003

Hackman, D. A., Farah, M. J., & Meaney, M. J. (2010). Socioeconomic status and the brain: mechanistic insights from human and animal research. *Nature Reviews. Neuroscience*, *11*(9), 651–659. https://doi.org/10.1038/nrn2897

Hampson, Driesen, Skudlarski, P., Gore, J., & Constable, R. (2006). Brain connectivity related to working memory performance. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*. https://doi.org/10.1523/JNEUROSCI.3408-06.2006

Harber, K. D., Yeung, D., & Iacovelli, A. (2011). Psychosocial resources, threat, and the perception of distance and height: Support for the resources and perception model. *Emotion*, *11*(5), 1080.

Hare, T. A., Tottenham, N., Galvan, A., Voss, H. U., Glover, G. H., & Casey, B. J. (2008). Biological substrates of emotional reactivity and regulation in adolescence during an emotional go-nogo task. *Biological Psychiatry*, *63*(10), 927–934.

Harm, M. W., & Seidenberg, M. S. (1999). Phonology, reading acquisition, and dyslexia: Insights from connectionist models. *Psychological Review*, *106*(3), 491–528.

Hartley, C. A., & Phelps, E. A. (2010). Changing fear: the neurocircuitry of emotion regulation. *Neuropsychopharmacology : Official Publication of the American College of Neuropsychopharmacology*, *35*(1), 136–146. https://doi.org/10.1038/npp.2009.121

Haskell, D. W., Foorman, B. R., & Swank, P. R. (1992). Effects of Three

Orthographic/Phonological Units on First-Grade Reading. *Remedial and Special Education*, *13*(2), 40–49. https://doi.org/10.1177/074193259201300207
Hattie, J., & Timperley, H. (2007). The Power of Feedback. *Review of Educational Research*, *77*(1), 81–112. https://doi.org/10.3102/003465430298487
Heyman, G. D., & Dweck, C. S. (1992). Achievement goals and intrinsic motivation: Their relation and their role in adaptive motivation. *Motivation and Emotion*, *16*(3), 231–247.
Heyneman, S. P., & Loxley, W. A. (1983). The Effect of Primary-School Quality on Academic Achievement Across Twenty-nine High- and Low-Income Countries. *American Journal of Sociology*, *88*(6), 1162–1194. https://doi.org/10.1086/227799
Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing*. https://doi.org/10.1007/BF00401799
Hummer, T. A., Kronenberger, W. G., Wang, Y., & Mathews, V. P. (2017). Decreased Prefrontal Activity During a Cognitive Inhibition Task Following Violent Video Game Play: A Multi-Week Randomized Trial. *Psychology of Popular Media Culture*. https://doi.org/10.1037/ppm0000141
Hummer, T. A., Wang, Y., Kronenberger, W. G., Mosier, K. M., Kalnin, A. J., Dunn, D. W., & Mathews, V. P. (2010). Short-Term Violent Video Game Play by Adolescents Alters Prefrontal Activity During Cognitive Inhibition. *Media Psychology*, *13*(2), 136–154. https://doi.org/10.1080/15213261003799854
Jenkinson, M., Beckmann, C. F., Behrens, T. E. J., Woolrich, M. W., & Smith, S. M. (2012). Fsl. *Neuroimage*, *62*(2), 782–790.
Johnson, A. D., Martin, A., Brooks-Gunn, J., & Petrill, S. A. (2008). Order in the House! Associations among Household Chaos, the Home Literacy Environment, Maternal Reading Ability, and Children's Early Reading. *Merrill-Palmer Quarterly (Wayne State University. Press)*, *54*(4), 445–472. https://doi.org/10.1353/mpq.0.0009
Johnstone, T., van Reekum, C. M., Urry, H. L., Kalin, N. H., & Davidson, R. J. (2007). Failure to regulate: counterproductive recruitment of top-down prefrontal-subcortical circuitry in major depression. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *27*(33), 8877–8884. https://doi.org/10.1523/JNEUROSCI.2063-07.2007
Jones, R. M., Somerville, L. H., Li, J., Ruberry, E. J., Powers, A., Mehta, N., … Casey, B. J. (2014). Adolescent-specific patterns of behavior and neural activity during social reinforcement learning. *Cognitive, Affective & Behavioral Neuroscience*, *14*(2), 683–697. https://doi.org/10.3758/s13415-014-0257-z
Kamins, M. L., & Dweck, C. S. (1999). Person versus process praise and criticism: implications for contingent self-worth and coping. *Developmental Psychology*, *35*(3), 835–847. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10380873
Katz, I., Assor, A., Kanat-Maymon, Y., & Bereby-Meyer, Y. (2006). Interest as a Motivational Resource: Feedback and Gender Matter, but Interest Makes the Difference. *Social Psychology of Education*, *9*(1), 27–42. https://doi.org/10.1007/s11218-005-2863-7
Kier, E. L., Staib, L. H., Davis, L. M., & Bronen, R. A. (2004). MR Imaging of the Temporal Stem: Anatomic Dissection Tractography of the Uncinate Fasciculus, Inferior Occipitofrontal Fasciculus, and Meyer's Loop of the Optic Radiation. *AJNR Am. J. Neuroradiol.*, *25*(5), 677–691. Retrieved from

http://www.ajnr.org/content/25/5/677.short

Kilpatrick, L., & Cahill, L. (2003). Amygdala modulation of parahippocampal and frontal regions during emotionally influenced memory storage. *NeuroImage*. https://doi.org/10.1016/j.neuroimage.2003.08.006

Kim, P., Evans, G. W., Angstadt, M., Ho, S. S., Sripada, C. S., Swain, J. E., … Phan, K. L. (2013). Effects of childhood poverty and chronic stress on emotion regulatory brain function in adulthood. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(46), 18442–18447. https://doi.org/10.1073/pnas.1308240110

Kliewer, W., Lepore, S. J., Oskin, D., & Johnson, P. D. (1998). The role of social and cognitive processes in children's adjustment to community violence. *Journal of Consulting and Clinical Psychology*, *66*(1), 199–209. https://doi.org/10.1037//0022-006X.66.1.199

Knutson, B., & Cooper, J. C. (2005). Functional magnetic resonance imaging of reward prediction. *Current Opinion in Neurology*, *18*(4), 411–417.

Knutson, B., Fong, G. W., Bennett, S. M., Adams, C. M., & Hommer, D. (2003). A region of mesial prefrontal cortex tracks monetarily rewarding outcomes: characterization with rapid event-related fMRI. *NeuroImage*, *18*(2), 263–272. https://doi.org/10.1016/S1053-8119(02)00057-5

Krieger, N., Rowley, D. L., Herman, A. A., & Avery, B. (1993). Racism, sexism, and social class: implications for studies of health, disease, and well-being. *American Journal of Preventive Medicine*.

Kumar, N., Kishore, J., & Gupta, N. (2012). Kuppuswamy′s socioeconomic scale: Updating income ranges for the year 2012. *Indian Journal of Public Health*, *56*(1), 103. https://doi.org/10.4103/0019-557X.96988

Kumar, P., Berghorst, L. H., Nickerson, L. D., Dutra, S. J., Goer, F. K., Greve, D. N., & Pizzagalli, D. a. (2014). Differential effects of acute stress on anticipatory and consummatory phases of reward processing. *Neuroscience*, *266*, 1–12. https://doi.org/10.1016/j.neuroscience.2014.01.058

Kuppuswamy, B. (1981). Manual of socioeconomic status scale (urban). *Delhi: Manasayan*.

Landis, J. R., & Koch, G. G. (1977). The Measurement of Observer Agreement for Categorical Data. *Biometrics*, *33*(1), 159. https://doi.org/10.2307/2529310

Lawrence, J. S., Crocker, J., & Blanton, H. (2011). Stigmatized and Dominant Cultural Groups Differentially Interpret Positive Feedback. *Journal of Cross-Cultural Psychology*, *42*(1), 165–169. https://doi.org/10.1177/0022022110383569

Lee, V. E., & Burkam, D. T. (2002). *Inequality at the starting gate : social background differences in achievement as children begin school*. Economic Policy Institute. Retrieved from https://eric.ed.gov/?id=ED470551

Leff, A. P., Crewes, H., Plant, G. T., Scott, S. K., Kennard, C., & Wise, R. J. S. (2001). The functional anatomy of single-word reading in patients with hemianopic and pure alexia. *Brain*, *124*(3), 510–521. https://doi.org/10.1093/brain/124.3.510

Lesch, M. F., & Martin, R. C. (1998). The representation of sublexical orthographic-phonologic correspondences: evidence from phonological dyslexia. *The Quarterly Journal of Experimental Psychology. A, Human Experimental Psychology*, *51*(4), 905–938. https://doi.org/10.1080/713755790

Lin, L., Atkinson, R. K., Christopherson, R. M., Joseph, S. S., & Harrison, C. J. (2013). Animated agents and learning: Does the type of verbal feedback they provide matter? *Computers & Education*, *67*(0), 239–249. https://doi.org/10.1016/j.compedu.2013.04.017

Liston, C., McEwen, B. S., & Casey, B. J. (2009). Psychosocial stress reversibly disrupts prefrontal processing and attentional control. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(3), 912–917. https://doi.org/10.1073/pnas.0807041106

Luna, B. (2009). Developmental changes in cognitive control through adolescence. *Advances in Child Development and Behavior*, *37*, 233–278. https://doi.org/10.1016/j.drugalcdep.2008.02.002.A

Lyon, G. R., Shaywitz, S. E., Shaywitz, B. A., Sl, B. a, Catts, H., Dickman, E., … Viall, T. (2003). A Definition of Dyslexia. *Annals of Dyslexia*, *53*(1), 1–14. https://doi.org/10.1007/s11881-003-0001-9

Maisog, J. M., Einbinder, E. R., Flowers, D. L., Turkeltaub, P. E., & Eden, G. F. (2008). A meta-analysis of functional neuroimaging studies of dyslexia. *Annals of the New York Academy of Sciences*, *1145*, 237–259. https://doi.org/10.1196/annals.1416.024

Malter-Cohen, M., Jing, D., Yang, R. R., Tottenham, N., Lee, F. S., & Casey, B. J. (2013). Early-life stress has persistent effects on amygdala function and development in mice and humans. *Proceedings of the National Academy of Sciences*, *110*(45), 18274–18278. https://doi.org/10.1073/pnas.1310163110

Malter Cohen, M., Jing, D., Yang, R. R., Tottenham, N., Lee, F. S., Casey, B. J., … Casey, B. J. (2013). Early-life stress has persistent effects on amygdala function and development in mice and humans. *Proceedings of the National Academy of Sciences*, *110*(45), 18274–18278. https://doi.org/10.1073/pnas.1310163110

Manoach, D. S., Schlaug, G., Siewert, B., Darby, D. G., Bly, B. M., Benfield, A., … Warach, S. (1997). Prefrontal cortex fMRI signal changes are correlated with working memory load. *Neuroreport*, *8*(2), 545–549.

Martin, Laura N., Delgado, M. R. (2007). Neural correlates of positive and negative emotion regulation. *Journal of Cognitive Neuroscience*, *19*, 776–798. https://doi.org/10.1162/jocn.2007.19.5.776

Mattheiss, S. R., Alexander, E. J., & Graves, W. W. (n.d.). Using lexical semantic ambiguity to distinguish information-specific from domain-general processing.

Mattheiss, S. R., Alexander, E. J., & Graves, W. W. (2018). Elaborative feedback: Engaging reward and task-relevant brain regions promotes learning in pseudoword reading aloud. *Cognitive, Affective, & Behavioral Neuroscience*, *18*(1), 68–87. https://doi.org/10.3758/s13415-017-0553-5

Mattheiss, S. R., Levinson, H., & Graves, W. W. (n.d.). Duality of function: Activation for meaningless nonwords and semantic codes in the same brain areas. *Cerebral Cortex*. https://doi.org/10.1002/adsc.201

Matthews, K. A., Gallo, L. C., & Taylor, S. E. (2010). Are psychosocial factors mediators of socioeconomic status and health connections? *Annals of the New York Academy of Sciences*, *1186*(1), 146–173. https://doi.org/10.1111/j.1749-6632.2009.05332.x

Maurer, U., Brem, S., Bucher, K., Kranz, F., Benz, R., Steinhausen, H.-C., & Brandeis, D. (2007). Impaired tuning of a fast occipito-temporal response for print in dyslexic children learning to read. *Brain : A Journal of Neurology*, *130*(Pt 12), 3200–3210.

https://doi.org/10.1093/brain/awm193
McEwen, B. S., & Gianaros, P. J. (2010). Central role of the brain in stress and adaptation: links to socioeconomic status, health, and disease. *Annals of the New York Academy of Sciences*, *1186*(1), 190–222. https://doi.org/10.1111/j.1749-6632.2009.05331.x
McEwen, B. S., & Morrison, J. H. (2013). The Brain on Stress: Vulnerability and Plasticity of the Prefrontal Cortex over the Life Course. *Neuron*. https://doi.org/10.1016/j.neuron.2013.06.028
McNorgan, C., Randazzo-Wagner, M., & Booth, J. R. (2013). Cross-modal integration in the brain is related to phonological awareness only in typical readers, not in those with reading difficulty. *Frontiers in Human Neuroscience*, *7*(July), 388. https://doi.org/10.3389/fnhum.2013.00388
Mendoza-Denton, R., Goldman-Flythe, M., Pietrzak, J., Downey, G., & Aceves, M. J. (2010). Group-Value Ambiguity. *Social Psychological and Personality Science*, *1*(2), 127–135. https://doi.org/10.1177/1948550609357796
Miller, G. A., Bruner, J. S., & Postman, L. (1954). Familiarity of letter sequences and tachistoscopic identification. *The Journal of General Psychology*, *50*(1), 129–139. https://doi.org/10.1080/00221309.1954.9710109
Mizoguchi, K., Yuzurihara, M., Ishige, a, Sasaki, H., Chui, D. H., & Tabira, T. (2000). Chronic stress induces impairment of spatial working memory because of prefrontal dopaminergic dysfunction. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *20*(4), 1568–1574. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10662846
Molnar, B. E., Gortmaker, S. L., Bull, F. C., & Buka, S. L. (2004). Unsafe to Play? Neighborhood Disorder and Lack of Safety Predict Reduced Physical Activity Among Urban Children and Adolescents. *American Journal of Health Promotion*, *18*(5), 378–386. https://doi.org/10.4278/0890-1171-18.5.378
Morais, J. (2003). Levels of phonological representation in skilled reading and in learning to read. *Reading and Writing: An Interdisciplinary Journal*, *16*(1/2), 123–151. https://doi.org/10.1023/a:1021702307703
Morgan, P. L., & Fuchs, D. (2007). Is There a Bidirectional Relationship Between Children's Reading Skills and Reading Motivation? *Exceptional Children*, *73*(2), 165–183. https://doi.org/Article
Mueller, C. W., & Parcel, T. L. (1981). Measures of Socioeconomic Status: Alternatives and Recommendations. *Child Development*, *52*(1), 13. https://doi.org/10.2307/1129211
Mueller, S. C., Maheu, F. S., Dozier, M., Peloso, E., Mandell, D., Leibenluft, E., … Ernst, M. (2010). Early-life stress is associated with impairment in cognitive control in adolescence: An fMRI study. *Neuropsychologia*, *48*(10), 3037–3044. https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2010.06.013
Nicaise, V., Cogérino, G., Bois, J., & Amorose, A. J. (2006). Students' Perceptions of Teacher Feedback and Physical Competence in Physical Education Classes: Gender Effects. *Journal of Teaching in Physical Education*, *25*(1), 36–57. https://doi.org/10.1123/jtpe.25.1.36
Nikolova, Y. S., Bogdan, R., Brigidi, B. D., & Hariri, A. R. (2012). Ventral Striatum Reactivity to Reward and Recent Life Stress Interact to Predict Positive Affect.

Biological Psychiatry, *72*(2), 157–163. https://doi.org/10.1016/j.biopsych.2012.03.014

Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking Rumination. *Perspectives on Psychological Science*, *3*(5), 400–424. https://doi.org/10.1111/j.1745-6924.2008.00088.x

Nooner, K. B., Mennes, M., Brown, S., Castellanos, F. X., Leventhal, B., Milham, M. P., & Colcombe, S. J. (2013). Relationship of trauma symptoms to amygdala-based functional brain changes in adolescents. *Journal of Traumatic Stress*, *26*(6), 784–787. https://doi.org/10.1002/jts.21873

O'Doherty, J. P. (2004). Reward representations and reward-related learning in the human brain: insights from neuroimaging. *Current Opinion in Neurobiology*, *14*(6), 769–776. https://doi.org/10.1016/j.conb.2004.10.016

Ochsner, K. N., Silvers, J. A., & Buhle, J. T. (2012). Functional imaging studies of emotion regulation: a synthetic review and evolving model of the cognitive control of emotion. *Annals of the New York Academy of Sciences*, *1251*, E1-24. https://doi.org/10.1111/j.1749-6632.2012.06751.x

Oei, N. Y. L., Veer, I. M., Wolf, O. T., Spinhoven, P., Rombouts, S. a R. B., & Elzinga, B. M. (2012). Stress shifts brain activation towards ventral "affective" areas during emotional distraction. *Social Cognitive and Affective Neuroscience*, *7*(4), 403–412. https://doi.org/10.1093/scan/nsr024

Orsolini, M., Fanari, R., Tosi, V., De Nigris, B., & Carrieri, R. (2006). From phonological recoding to lexical reading: A longitudinal study on reading development in Italian. *Language and Cognitive Processes*, *21*(5), 576–607. https://doi.org/10.1080/01690960500139355

Ossewaarde, L., Qin, S., Van Marle, H. J. F., van Wingen, G. A., Fernández, G., & Hermans, E. J. (2011). Stress-induced reduction in reward-related prefrontal cortex function. *NeuroImage*, *55*(1), 345–352. https://doi.org/10.1016/j.neuroimage.2010.11.068

Owen, A. M., McMillan, K. M., Laird, A. R., & Bullmore, E. (2005). N-Back working memory paradigm: A meta-analysis of normative functional neuroimaging studies. *Hum Brain Mapp*, *25*(1), 46–59. https://doi.org/10.1002/hbm.20131

Padmala, S., Sirbu, M., & Pessoa, L. (2017). Potential reward reduces the adverse impact of negative distractor stimuli. *Social Cognitive and Affective Neuroscience*, *15*(28), 2347–2351. https://doi.org/10.1093/scan/nsx067

Pan, X., Hu, Y., Li, L., & Li, J. (2009). Evaluative-feedback stimuli selectively activate the self-related brain area: An fMRI study. *Neuroscience Letters*, *465*(1), 90–94. https://doi.org/http://dx.doi.org.proxy.libraries.rutgers.edu/10.1016/j.neulet.2009.08.070

Pechtel, P., & Pizzagalli, D. A. (2011). Effects of early life stress on cognitive and affective function: an integrated review of human literature. *Psychopharmacology*, *214*(1), 55–70. https://doi.org/10.1007/s00213-010-2009-2

Peirce, J. W. (2007). PsychoPy--Psychophysics software in Python. *Journal of Neuroscience Methods*, *162*(1–2), 8–13. https://doi.org/10.1016/j.jneumeth.2006.11.017

Pereira, M. G., de Oliveira, L., Erthal, F. S., Joffily, M., Mocaiber, I. F., Volchan, E., & Pessoa, L. (2010). Emotion affects action: Midcingulate cortex as a pivotal node of

interaction between negative emotion and motor signals. *Cognitive, Affective & Behavioral Neuroscience*, *10*(1), 94–106. https://doi.org/10.3758/CABN.10.1.94
Petzold, A., Plessow, F., Goschke, T., & Kirschbaum, C. (2010). Stress reduces use of negative feedback in a feedback-based learning task. *Behavioral Neuroscience*, *124*(2), 248.
Phelps, E. A., Delgado, M. R., Nearing, K. I., & LeDoux, J. E. (2004). Extinction Learning in Humans: Role of the Amygdala and vmPFC. *Neuron*, *43*(6), 897–905. https://doi.org/10.1016/j.neuron.2004.08.042
Philip, N. S., Sweet, L. H., Tyrka, A. R., Carpenter, S. L., Albright, S. E., Price, L. H., & Carpenter, L. L. (2016). Exposure to childhood trauma is associated with altered n-back activation and performance in healthy adults: implications for a commonly used working memory task. *Brain Imaging and Behavior*, *10*(1), 124–135. https://doi.org/10.1007/s11682-015-9373-9
Price, C. J. (2012). A review and synthesis of the first 20 years of PET and fMRI studies of heard speech, spoken language and reading. *NeuroImage*, *62*(2), 816–847. https://doi.org/10.1016/j.neuroimage.2012.04.062
Qin, S., Hermans, E. J., van Marle, H. J. F., Luo, J., & Fernández, G. (2009). Acute psychological stress reduces working memory-related activity in the dorsolateral prefrontal cortex. *Biological Psychiatry*, *66*(1), 25–32. https://doi.org/10.1016/j.biopsych.2009.03.006
Raio, C. M., Orederu, T. a, Palazzolo, L., Shurick, A. a, & Phelps, E. a. (2013). Cognitive emotion regulation fails the stress test. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(37), 15139–15144. https://doi.org/10.1073/pnas.1305706110
Ramsey, J. D., Hanson, S. J., & Glymour, C. (2011). Multi-subject search correctly identifies causal connections and most causal directions in the DCM models of the Smith et al. simulation study. *NeuroImage*. https://doi.org/10.1016/j.neuroimage.2011.06.068
Ramsey, J. D., Hanson, S. J., Hanson, C., Halchenko, Y. O., Poldrack, R. a, & Glymour, C. (2010). Six problems for causal inference from fMRI. *NeuroImage*, *49*(2), 1545–1558. https://doi.org/10.1016/j.neuroimage.2009.08.065
Richlan, F., Kronbichler, M., & Wimmer, H. (2009). Functional abnormalities in the dyslexic brain: a quantitative meta-analysis of neuroimaging studies. *Human Brain Mapping*, *30*(10), 3299–3308. https://doi.org/10.1002/hbm.20752
Richters, J. E., & Martinez, P. (1993). The NIMH community violence project: I. Children as victims of and witnesses to violence. *Psychiatry*, *56*(1), 7–21. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8488215
Richters, J. E., & Saltzman, W. (1990). *Survey of exposure to community violence: Self-report version*. Rockville, MD: National Institute of Mental Health: JE Richters.
Richters, J., & Saltzman, W. (1990). Survey of exposure to community violence: Self report version., (June 1990). https://doi.org/10.13140/RG.2.2.13714.04808
Roelofs, K., Bakvis, P., Hermans, E. J., van Pelt, J., & van Honk, J. (2007). The effects of social stress and cortisol responses on the preconscious selective attention to social threat. *Biological Psychology*, *75*(1), 1–7. https://doi.org/10.1016/j.biopsycho.2006.09.002
Roeltgen, D. P., Sevush, S., & Heilman, K. M. (1983). Pure Gerstmann’s Syndrome From

a Focal Lesion. *Archives of Neurology*, *40*(1), 46–47. https://doi.org/10.1001/archneur.1983.04050010066019

Rosenberg, M. (1979). Rosenberg Self-Esteem Scale (RSE). In *Conceiving the Self*. https://doi.org/10.1177/0145445507302037

Rowe, J. B., Toni, I., Josephs, O., Frackowiak, R. S. J., & Passingham, R. E. (2000). The Prefrontal Cortex: Response Selection or Maintenance Within Working Memory? *Science*. https://doi.org/10.1126/science.288.5471.1656

Rumsey, J. M., Horwitz, B., Donohue, B. C., Nace, K., Maisog, J. M., & Andreason, P. (1997). Phonological and orthographic components of word recognition. A PET-rCBF study. *Brain : A Journal of Neurology*, *120 (Pt 5*, 739–759. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9183247

Saad, Z. S., Glen, D. R., Chen, G., Beauchamp, M. S., Desai, R., & Cox, R. W. (2009). A new method for improving functional-to-structural MRI alignment using local Pearson correlation. *NeuroImage*, *44*(3), 839–848. https://doi.org/10.1016/j.neuroimage.2008.09.037

Sampson, R. J. (1997). Neighborhoods and Violent Crime: A Multilevel Study of Collective Efficacy. *Science*, *277*(5328), 918–924. https://doi.org/10.1126/science.277.5328.918

Schmeichel, B. J., & Demaree, H. A. (2010). Working memory capacity and spontaneous emotion regulation: High capacity predicts self-enhancement in response to negative feedback. *Emotion*, *10*(5), 739–744.

Schnall, S., Harber, K. D., Stefanucci, J. K., & Proffitt, D. R. (2008). Social support and the perception of geographical slant. *Journal of Experimental Social Psychology*, *44*(5), 1246–1255. https://doi.org/10.1016/j.jesp.2008.04.011

Shackman, J. E., Shackman, A. J., & Pollak, S. D. (2007). Physical abuse amplifies attention to threat and increases anxiety in children. *Emotion*, *7*(4), 838–852. https://doi.org/10.1037/1528-3542.7.4.838

Sharkey, P. (2010). The acute effect of local homicides on children's cognitive performance. *Proceedings of the National Academy of Sciences*, *107*(26), 11733–11738. https://doi.org/10.1073/pnas.1000690107

Sharkey, P., Schwartz, A. E., Ellen, I. G., & Lacoe, J. (2014). High Stakes in the Classroom, High Stakes on the Street: The Effects of Community Violence on Student's Standardized Test Performance. *Sociological Science*, *1*(May), 199–220. https://doi.org/10.15195/v1.a14

Sharkey, P. T., Tirado-Strayer, N., Papachristos, A. V, & Raver, C. C. (2012). The effect of local violence on children's attention and impulse control. *American Journal of Public Health*, *102*(12), 2287–2293. https://doi.org/10.2105/AJPH.2012.300789

Shaywitz, S. E., Fletcher, J. M., Holahan, J. M., Shneider, A. E., Marchione, K. E., Stuebing, K. K., … Shaywitz, B. A. (1999). Persistence of dyslexia: the Connecticut Longitudinal Study at adolescence. *Pediatrics*, *104*(6), 1351–1359. https://doi.org/10.1542/peds.104.6.1351

Shaywitz, S. E., & Shaywitz, B. A. (2005). Dyslexia (Specific Reading Disability). *Biological Psychiatry*, *57*(11), 1301–1309. https://doi.org/10.1016/j.biopsych.2005.01.043

Shin, L. M., Wright, C. I., Cannistraro, P. A., Wedig, M. M., McMullin, K., Martis, B., … Rauch, S. L. (2005). A Functional Magnetic Resonance Imaging Study of Amygdala and Medial Prefrontal Cortex Responses to Overtly Presented Fearful Faces in Posttraumatic Stress Disorder. *Archives of General Psychiatry*, *62*(3), 273. https://doi.org/10.1001/archpsyc.62.3.273

Silvers, J. A., Insel, C., Powers, A., Franz, P., Helion, C., Martin, R. E., … Ochsner, K. N. (2017). VlPFC-vmPFC-Amygdala Interactions Underlie Age-Related Differences in Cognitive Regulation of Emotion. *Cerebral Cortex*. https://doi.org/10.1093/cercor/bhw073

Sinha, R. (2008). Chronic stress, drug use, and vulnerability to addiction. *Annals of the New York Academy of Sciences*, *1141*, 105–130. https://doi.org/10.1196/annals.1441.030

Sirin, S. R. (2005). Socioeconomic Status and Academic Achievement: A Meta-Analytic Review of Research. *Review of Educational Research*, *75*(3), 417–453. https://doi.org/10.3102/00346543075003417

Smith, D. V., & Delgado, M. R. (2015). Reward Processing. In *Brain Mapping: an Encyclopedic Reference*.

Somerville, L. H., Kelley, W. M., & Heatherton, T. F. (2010). Self-esteem modulates medial prefrontal cortical responses to evaluative social feedback. *Cerebral Cortex (New York, N.Y. : 1991)*, *20*(12), 3005–3013. https://doi.org/10.1093/cercor/bhq049

Steptoe, a, & Feldman, P. J. (2001). Neighborhood problems as sources of chronic stress: development of a measure of neighborhood problems, and associations with socioeconomic status and health. *Annals of Behavioral Medicine : A Publication of the Society of Behavioral Medicine*, *23*(3), 177–185. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11495218

Takeuchi, H., Sekiguchi, A., Taki, Y., Yokoyama, S., Yomogida, Y., Komuro, N., … Kawashima, R. (2010). Training of Working Memory Impacts Structural Connectivity. *Journal of Neuroscience*, *30*(9), 3297–3303. https://doi.org/10.1523/JNEUROSCI.4611-09.2010

Talairach, J., & Tournoux, P. (1988). *Co-planar stereotaxic axis of the human brain. Stuttgart, Thieme.* Stuttgart, Thieme.

Temple, E., Deutsch, G. K., Poldrack, R. A., Miller, S. L., Tallal, P., Merzenich, M. M., & Gabrieli, J. D. E. (2003). Neural deficits in children with dyslexia ameliorated by behavioral remediation: Evidence from functional MRI. *Proceedings of the National Academy of Sciences*, *100*(5), 2860–2865. https://doi.org/10.1073/pnas.0030098100

Thomason, M. E., Marusak, H. A., Tocco, M. A., Vila, A. M., McGarragle, O., & Rosenberg, D. R. (2015). Altered amygdala connectivity in urban youth exposed to trauma. *Social Cognitive and Affective Neuroscience*, *10*(11), 1460–1468. https://doi.org/10.1093/scan/nsv030

Tighe, E. L., Wagner, R. K., & Schatschneider, C. (2015). Applying a multiple group causal indicator modeling framework to the reading comprehension skills of third, seventh, and tenth grade students. *Reading and Writing*, *28*(4), 439–466. https://doi.org/10.1007/s11145-014-9532-1

Torgesen, J. K. (2006). Recent Discoveries from Research on Remedial Interventions for Children with Dyslexia Joseph K . Torgesen Florida State University and the Florida Center for Reading Research. In M. J. Snowling & C. Hulme (Eds.), *The Science of Readng: A Handbook* (pp. 521–537). John Wiley & Sons.

Torgesen, J. K., Wagner, R. K., & Rashotte, C. A. (2012). TOWRE-2: Test of Word

Recognition Efficiency–. Austin, TX: Pro-Ed.
Torgesen, J. K., Wagner, R., & Rashotte, C. (1999). TOWRE Test of Word Reading Efficiency. *Austin, TX: Pro-Ed*.
Tottenham, N., Hare, T. A., Millner, A., Gilhooly, T., Zevin, J. D., & Casey, B. J. (2011). Elevated amygdala response to faces following early deprivation. *Developmental Science*, *14*(2), 190–204. https://doi.org/10.1111/j.1467-7687.2010.00971.x
Tottenham, N., Hare, T. A., Quinn, B. T., McCarry, T. W., Nurse, M., Gilhooly, T., … Casey, B. J. J. (2010). Prolonged institutional rearing is associated with atypically large amygdala volume and difficulties in emotion regulation. *Developmental Science*, *13*(1), 46–61. https://doi.org/10.1111/j.1467-7687.2009.00852.x
Tottenham, N., & Sheridan, M. A. (2010). A review of adversity, the amygdala and the hippocampus: a consideration of developmental timing. *Frontiers in Human Neuroscience*, *3*, 68. https://doi.org/10.3389/neuro.09.068.2009
Treadway, M. T., Buckholtz, J. W., & Zald, D. H. (2013). Perceived stress predicts altered reward and loss feedback processing in medial prefrontal cortex. *Frontiers in Human Neuroscience*, *7*, 180. https://doi.org/10.3389/fnhum.2013.00180
Tressoldi, P. E., Vio, C., & Iozzino, R. (2007). Efficacy of an intervention to improve fluency in children with developmental dyslexia in a regular orthography. *Journal of Learning Disabilities*, *40*(3), 203–209. https://doi.org/10.1177/00222194070400030201
Tricomi, E., Delgado, M. R., McCandliss, B. D., McClelland, J. L., & Fiez, J. a. (2006). Performance feedback drives caudate activation in a phonological learning task. *Journal of Cognitive Neuroscience*, *18*(6), 1029–1043. https://doi.org/10.1162/jocn.2006.18.6.1029
Tricomi, E. M., Delgado, M. R., & Fiez, J. A. (2004). Modulation of Caudate Activity by Action Contingency. *Neuron*, *41*(2), 281–292. https://doi.org/10.1016/S0896-6273(03)00848-1
Tsavoussis, A., Stawicki, S. P. A., Stoicea, N., & Papadimos, T. J. (2014). Child-witnessed domestic violence and its adverse effects on brain development: a call for societal self-examination and awareness. *Frontiers in Public Health*, *2*, 178. https://doi.org/10.3389/fpubh.2014.00178
Turkeltaub, P. E., Eden, G. F., Jones, K. M., & Zeffiro, T. A. (2002). Meta-Analysis of the Functional Neuroanatomy of Single-Word Reading: Method and Validation. *NeuroImage*, *16*(3), 765–780. https://doi.org/10.1006/nimg.2002.1131
Urry, H. L., van Reekum, C. M., Johnstone, T., Kalin, N. H., Thurow, M. E., Schaefer, H. S., … Davidson, R. J. (2006). Amygdala and ventromedial prefrontal cortex are inversely coupled during regulation of negative affect and predict the diurnal pattern of cortisol secretion among older adults. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *26*(16), 4415–4425. https://doi.org/10.1523/JNEUROSCI.3215-05.2006
van Dam, W. O., Decker, S. L., Durbin, J. S., Vendemia, J. M. C., & Desai, R. H. (2015). Resting state signatures of domain and demand-specific working memory performance. *NeuroImage*. https://doi.org/10.1016/j.neuroimage.2015.05.017
van den Heuvel, M. P., & Hulshoff Pol, H. E. (2010). Exploring the brain network: a review on resting-state fMRI functional connectivity. *European Neuropsychopharmacology : The Journal of the European College of*

Neuropsychopharmacology, *20*(8), 519–534. https://doi.org/10.1016/j.euroneuro.2010.03.008

van Duijvenvoord, A. C. K., Zanolie, K., Rombouts, S. a R. B., Raijmakers, M. E. J., & Crone, E. A. (2008). Evaluating the negative or valuing the positive? Neural mechanisms supporting feedback-based learning across development. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *28*(38), 9495–9503. https://doi.org/10.1523/JNEUROSCI.1485-08.2008

van Marle, H. J. F., Hermans, E. J., Qin, S., & Fernández, G. (2009). From specificity to sensitivity: how acute stress affects amygdala processing of biologically salient stimuli. *Biological Psychiatry*, *66*(7), 649–655. https://doi.org/10.1016/j.biopsych.2009.05.014

Vellutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): what have we learned in the past four decades? *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *45*(1), 2–40. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/14959801

Vellutino, F., Scanlon, D., & Spearing, D. (1995). Semantic and phonological coding in poor and normal readers. *Journal of Experimental Child Psychology*, *59*(1), 76–123. Retrieved from http://www.sciencedirect.com/science/article/pii/S0022096585710041

Verhoeven, L., & van Leeuwe, J. (2008). Prediction of the development of reading comprehension: A longitudinal study. *Applied Cognitive Psychology*. https://doi.org/10.1002/acp

Vinckier, F., Dehaene, S., Jobert, A., Dubus, J. P., Sigman, M., & Cohen, L. (2007). Hierarchical Coding of Letter Strings in the Ventral Stream: Dissecting the Inner Organization of the Visual Word-Form System. *Neuron*, *55*(1), 143–156. https://doi.org/10.1016/j.neuron.2007.05.031

Vink, M., Pas, P., Bijleveld, E., Custers, R., & Gladwin, T. E. (2013). Ventral striatum is related to within-subject learning performance. *Neuroscience*, *250*, 408–416. https://doi.org/10.1016/j.neuroscience.2013.07.034

Vitevitch, M. S., & Luce, P. A. (1998). When Words Compete: Levels of Processing in Perception of Spoken Words. *Psychological Science*, *9*(4), 325–329. https://doi.org/10.1111/1467-9280.00064

Vogt, B. A., Berger, G. R., & Derbyshire, S. W. G. (2003). Structural and functional dichotomy of human midcingulate cortex. *The European Journal of Neuroscience*, *18*(11), 3134–3144. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/14656310

Walker, S. P., Wachs, T. D., Grantham-McGregor, S., Black, M. M., Nelson, C. A., Huffman, S. L., … Richter, L. (2011). Inequality in early childhood: risk and protective factors for early child development. *The Lancet*, *378*(9799), 1325–1338. https://doi.org/10.1016/S0140-6736(11)60555-2

Wechsler, D. (2001). Wechsler Test of Adult Reading: (WTAR). San Antonio, TX: Psychological Corporation.

Wentink, H. W. M. J., Van Bon, W. H. J., & Schreuder, R. (1997). Training of poor readers’ phonological decoding skills: Evidence for syllable-bound processing. *Reading and Writing*, *9*(3), 163–192. https://doi.org/10.1023/A:1007921805360

Williams, J. P. (1980). Teaching decoding with an emphasis on phoneme analysis and phoneme blending. *Journal of Educational Psychology*, *72*(1), 1–15.

Yeager, D. S., Purdie-Vaughns, V., Garcia, J., Apfel, N., Brzustoski, P., Master, A., … Cohen, G. L. (2014). Breaking the cycle of mistrust: Wise interventions to provide critical feedback across the racial divide. *Journal of Experimental Psychology: General*, *143*(2), 804.

Yokoyama, T., Padmala, S., & Pessoa, L. (2015). Reward learning and negative emotion during rapid attentional competition. *Frontiers in Psychology*, *6*(MAR), 1–10. https://doi.org/10.3389/fpsyg.2015.00269

Zanolie, K., Teng, S., Donohue, S. E., van Duijvenvoorde, A. C. K., Band, G. P. H., Rombouts, S. A. R. B., & Crone, E. A. (2008). Switching between colors and shapes on the basis of positive and negative feedback: an fMRI and EEG study on feedback-based learning. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *44*(5), 537–547. https://doi.org/10.1016/j.cortex.2007.11.005

Zanolie, K., Van Leijenhorst, L., Rombouts, S. A. R. B., & Crone, E. A. (2008). Separable neural mechanisms contribute to feedback processing in a rule-learning task. *Neuropsychologia*. https://doi.org/10.1016/j.neuropsychologia.2007.08.009

Zanolie, K., Van Leijenhorst, L., Rombouts, S. A. R. B., Crone, E. A., Leijenhorst, L. Van, Rombouts, S. A. R. B., & Crone, E. A. (2008). Separable neural mechanisms contribute to feedback processing in a rule-learning task. *Neuropsychologia*, *46*(1), 117–126. https://doi.org/10.1016/j.neuropsychologia.2007.08.009

Zimet, G. D., Dahlem, N. W., Zimet, S. G., & Farley, G. D. (1988). The multidimensional scale of perceived social support. *Journal of Personality Assessment*, *52*(1), 30–41. https://doi.org/10.1037/t03506-

Appendices

A. Survey of Exposure to Community Violence, (Modified from Richters & Saltzman, 1990); Current Violence (Studies 1-3)

These next questions ask about things you have seen or heard **in the past year**. For each item, please circle how often you have seen each thing around your home or your neighborhood. Please DO NOT count things you might have seen on television.

1. IN THE LAST YEAR: Have you heard guns being shot?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

2. IN THE LAST YEAR: Have you seen drug deals?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

3. IN THE LAST YEAR: Have you seen someone being beaten up?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

4. IN THE LAST YEAR: Have you seen somebody get stabbed?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

5. IN THE LAST YEAR: Have you seen somebody get shot?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

6. IN THE LAST YEAR: Have you seen gangs in your neighborhood?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

7. IN THE LAST YEAR: Have you seen somebody pull a gun on another person?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

8. IN THE LAST YEAR: Have you heard other people talk about having weapons?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

9. IN THE LAST YEAR: Have you seen other people with guns or knives in your neighborhood?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

10. IN THE LAST YEAR: Have you heard other people threatening to beat someone up or hurt someone?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

11. IN THE LAST YEAR: Have you seen people helping each other with house work, yard work, or with their cars?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

12. IN THE LAST YEAR: Have you seen other people get hit or pushed?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

13. IN THE LAST YEAR: Have you been hit or pushed by someone?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

14. IN THE LAST YEAR: Have other people helped you with something?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

15. IN THE LAST YEAR: Have other people threatened to hurt you?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

16. IN THE LAST YEAR: Have you seen people break windows on cars or buildings on purpose?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

17. IN THE LAST YEAR: Have you seen people tag or spray paint works or pictures on buildings or other places?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

Please indicate the degree to which the exposure to violence you reported was in your home (domestic).

- None at all
- A little
- A moderate amount
- A lot
- A great deal
- All

Q23 Please indicate the degree to which the exposure to violence you reported was in your neighborhood.

- ◯ None at all
- ◯ A little
- ◯ A moderate amount
- ◯ A lot
- ◯ A great deal
- ◯ All

Q25 How often do you think about the violent events that you have experienced?

- ◯ Never
- ◯ Sometimes
- ◯ About half the time
- ◯ Most of the time
- ◯ Always

B. Survey of Exposure to Community Violence, Modified from Richters & Saltzman, 1990); Childhood Violence (Studies 1-3)

These next questions ask about things you have seen or heard **during the ages of 3 to 14**. For each item, please circle how often you have seen each thing around your home or your neighborhood. Please DO NOT count things you might have seen on television.

1. DURING THE AGES OF 3 TO 14: Have you heard guns being shot?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

2. DURING THE AGES OF 3 TO 14: Have you seen drug deals?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

3. DURING THE AGES OF 3 TO 14: Have you seen someone being beaten up?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

4. DURING THE AGES OF 3 TO 14: Have you seen somebody get stabbed?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

5. DURING THE AGES OF 3 TO 14: Have you seen somebody get shot?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

6. DURING THE AGES OF 3 TO 14: Have you seen gangs in your neighborhood?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

7. DURING THE AGES OF 3 TO 14: Have you seen somebody pull a gun on another person?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

8. DURING THE AGES OF 3 TO 14: Have you heard other people talk about having weapons?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

9. DURING THE AGES OF 3 TO 14: Have you seen other people with guns or knives in your neighborhood?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

10. DURING THE AGES OF 3 TO 14: Have you heard other people threatening to beat someone up or hurt someone?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

11. DURING THE AGES OF 3 TO 14: Have you seen people helping each other with house work, yard work, or with their cars?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

12. DURING THE AGES OF 3 TO 14: Have you seen other people get hit or pushed?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

13. DURING THE AGES OF 3 TO 14: Have you been hit or pushed by someone?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

14. DURING THE AGES OF 3 TO 14: Have other people helped you with something?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

15. DURING THE AGES OF 3 TO 14: Have other people threatened to hurt you?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

16. DURING THE AGES OF 3 TO 14: Have you seen people break windows on cars or buildings on purpose?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

17. DURING THE AGES OF 3 TO 14: Have you seen people tag or spray paint works or pictures on buildings or other places?

1. Yes, many times 2. Yes, a few times 3. Yes, once or twice 4. No

Please indicate the degree to which the exposure to violence you reported was in your home (domestic).

- ◯ None at all
- ◯ A little
- ◯ A moderate amount
- ◯ A lot
- ◯ A great deal
- ◯ All

Q23 Please indicate the degree to which the exposure to violence you reported was in your neighborhood.

- ◯ None at all
- ◯ A little
- ◯ A moderate amount
- ◯ A lot
- ◯ A great deal
- ◯ All

Q25 How often do you think about the violent events that you have experienced?

- ◯ Never
- ◯ Sometimes
- ◯ About half the time
- ◯ Most of the time
- ◯ Always

C. Likert Scales (Study 1)

1. To what degree did you experience difficulty, as a child, in learning to read?

   1 2 3 4 5

   No difficulty at all *Severe difficulty*

2. To what degree do you experience difficulty, as an adult, in reading?

   1 2 3 4 5

   No difficulty at all *Severe difficulty*

3. To what degree was the following feedback helpful: “It's always best to blend – ---.”

   1 2 3 4 5

   Not helpful at all *Very helpful*

4. To what degree was the following feedback helpful: “Excellent, you blended – ---.”

   1 2 3 4 5

   Not helpful at all *Very helpful*

5. To what degree was the following feedback helpful: “Excellent, you got it correct.”

   1 2 3 4 5

   Not helpful at all *Very helpful*

6. To what degree was the following feedback pleasant: “It's always best to blend – ---.”

   1 2 3 4 5

   Very unpleasant *Very pleasant*

7. To what degree was the following feedback pleasant: “Excellent, you blended – ---.”
   1 2 3 4 5

   Very unpleasant *Very pleasant*

8. To what degree was the following feedback pleasant: “Excellent, you got it correct.”
   1 2 3 4 5

   Very unpleasant *Very pleasant*

D. Measure of socioeconomic status (Studies 1-2)

Kuppuswamy, B. (1962). Socio-economic status scale (Urban). *Delhi: Mansayan*.

A) Education of head of household

- Professional degree, postgraduate, and above
- BA or BSc degree
- Intermediate or post high school diploma
- High school certificate
- Middle school certificate
- Primary school certificate
- Illiterate

B) Occupation of the head of household (last occupation in case of retired persons)

- Professional
- Semi-professional
- Clerical, shop-owner, farmer
- Skilled worker
- Semi-skilled worker
- Unskilled worker
- Unemployed

C) Per capita income ($ Per month)

- 2616 and above
- 1308-2615
- 981-1307
- 654-980
- 392-653
- 130-391
- <130

E. Likert Scales (Study 3)

Please answer each question as best as you can.

Q3 To what degree did you find the following type of feedback rewarding?
Excellent, you got it correct.

- ◯ 1; Did not feel good at all (15)
- ◯ 2 (16)
- ◯ 3 (17)
- ◯ 4 (18)
- ◯ 5 (19)
- ◯ 6 (20)
- ◯ 7: Felt extremely good (21)

Q22 To what degree did you find the following types of feedback rewarding?
It's best for you to blend ---------.
It is best for you to blend --------.

- ◯ 1; Did not feel good at all (15)
- ◯ 2 (16)
- ◯ 3 (17)
- ◯ 4 (18)
- ◯ 5 (19)
- ◯ 6 (20)
- ◯ 7: Felt extremely good (21)

Q23 To what degree did you find the following types of feedback rewarding?
Excellent, you blended --------.
Excellent, you just blended --------.

- ◯ 1; Did not feel good at all (15)
- ◯ 2 (16)
- ◯ 3 (17)
- ◯ 4 (18)
- ◯ 5 (19)
- ◯ 6 (20)
- ◯ 7: Felt extremely good (21)

Q34 To what degree did you find the following type of feedback content-informative?
Excellent, you got it correct.

- ◯ 1; Did not at all inform me about how to blend the word (15)
- ◯ 2 (16)
- ◯ 3 (17)
- ◯ 4 (18)
- ◯ 5 (19)
- ◯ 6 (20)
- ◯ 7: Completely informed me about how to blend the word (21)

Q35 To what degree did you find the following types of feedback content-informative?
It's best for you to blend ---------.
It is best for you to blend --------.

- 1; Did not at all inform me about how to blend the word (15)
- 2 (16)
- 3 (17)
- 4 (18)
- 5 (19)
- 6 (20)
- 7: Completely informed me about how to blend the word (21)

Q36 To what degree did you find the following types of feedback content-informative?
Excellent, you blended --------.
Excellent, you just blended --------.

- 1; Did not at all inform me about how to blend the word (15)
- 2 (16)
- 3 (17)
- 4 (18)
- 5 (19)
- 6 (20)
- 7: Completely informed me about how to blend the word (21)

Q40 To what degree did you find the following type of feedback self-relevant?
Excellent, you got it correct.

- 1; Not at all relevant to me or the action I took (15)
- 2 (16)
- 3 (17)
- 4 (18)
- 5 (19)
- 6 (20)
- 7: Extremely relevant to me and the action I took (21)

Q41 To what degree did you find the following types of feedback self-relevant?
It's best for you to blend ---------.
It is best for you to blend --------.

- 1; Not at all relevant to me or the action I took (15)
- 2 (16)
- 3 (17)
- 4 (18)
- 5 (19)
- 6 (20)
- 7: Extremely relevant to me and the action I took (21)

Q42 To what degree did you find the following types of feedback self-relevant?
Excellent, you blended --------.
Excellent, you just blended --------.

- 1; Not at all relevant to me or the action I took (15)
- 2 (16)
- 3 (17)
- 4 (18)
- 5 (19)
- 6 (20)
- 7: Extremely relevant to me and the action I took (21)

Q43 To what degree did you find the following type of feedback make you feel like a good reader?
Excellent, you got it correct.

- 1; Did not at all make me feel like a good reader (15)
- 2 (16)
- 3 (17)
- 4 (18)
- 5 (19)
- 6 (20)
- 7: Made me feel like an excellent reader (21)

Q44 To what degree did you find the following types of feedback make you feel like a good reader?
It's best for you to blend ---------.
It is best for you to blend --------.

- 1; Did not at all make me feel like a good reader (15)
- 2 (16)
- 3 (17)
- 4 (18)
- 5 (19)
- 6 (20)
- 7: Made me feel like an excellent reader (21)

Q45 To what degree did you find the following types of feedback make you feel like a good reader?
Excellent, you blended --------.
Excellent, you just blended --------.

- 1; Did not at all make me feel like a good reader (15)
- 2 (16)
- 3 (17)
- 4 (18)
- 5 (19)
- 6 (20)
- 7: Made me feel like an excellent reader (21)

Q48 Did this feedback indicate a correct or incorrect answer?
It's best for you to blend --------.
It is best for you to to blend -------.

- Correct (1)
- Incorrect (2)

Q46 Please estimate the number of books you had in your house while you were growing up:

- ◯ None (8)
- ◯ 1-20 (1)
- ◯ 21-40 (2)
- ◯ 41-60 (3)
- ◯ 61-80 (4)
- ◯ 81-100 (5)
- ◯ More than 100 (7)

Q47 Please record all schools you attended from Kindergarten to College.

____
____
____
____
____

Q49 Please rate the quality of the schools you attended from PreK- 5th grade:

- ◯ 1. Extremely poor (1)
- ◯ 2. Very Poor (2)
- ◯ 3. Somewhat poor (3)
- ◯ 4. Mediocre (4)
- ◯ 5. Good (5)
- ◯ 6. Very good (6)
- ◯ 7. Excellent (7)

Q50 Please rate the quality of the schools you attended from 6th to 8th grade:

- ◯ 1. Extremely poor (1)
- ◯ 2. Very Poor (2)
- ◯ 3. Somewhat poor (3)
- ◯ 4. Mediocre (4)
- ◯ 5. Good (5)
- ◯ 6. Very good (6)
- ◯ 7. Excellent (7)

Q51 Please rate the quality of the schools you attended from 9th to 12th grade:

- ◯ 1. Extremely poor (1)
- ◯ 2. Very Poor (2)
- ◯ 3. Somewhat poor (3)
- ◯ 4. Mediocre (4)
- ◯ 5. Good (5)
- ◯ 6. Very good (6)
- ◯ 7. Excellent (7)

F. Measure of parental socioeconomic status (Studies 2- 3)

Q1 Please choose the best estimate of your annual household income (based on parental or guardian income):

- ○ 0-$10,000
- ○ $10,001-$20,000
- ○ $20,001-$30,000
- ○ $30,001-$40,000
- ○ $40,001-$50,000
- ○ $50,001-$60,000
- ○ $60,001-$70,000
- ○ $70,001-$80,000
- ○ $80,001-$90,000
- ○ $90,001-$100,000
- ○ $100,001 or more

Q2 Please choose the employment status that best describes the head of your household (parent or guardian with the higher employment status):

- ○ Unemployed
- ○ 20 hours or less per week
- ○ 21-30 hours per week
- ○ 31-40 hours per week
- ○ 41 or more hours per week

Q3 Please choose the highest level of education attained in your household (parent or guardian):

- ○ G.E.D.
- ○ High School
- ○ Some College
- ○ College Graduate
- ○ Other ____