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Elucidating the neurobiology of cyberbullying using functional Magnetic Resonance Imaging (fMRI): A hypothesis

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ABSTRACT

Cyberbullying is a prevalent concern around the world. Research shows that interactions online are associated with similar structural correlates and patterns of brain activity to real-world (offline) relationships, and that the brain experiences peer victimisation (e.g., cyberbullying) in the same way that it experiences physical pain. Furthermore, these experiences can become biologically embedded in the physiology of the developing person, thereby increasing their risk of developing mental health problems. With the increasing prevalence of cyberbullying and youth internet usage, there is a pressing need to further understand the brain's response to cyberbullying.

We hypothesise that a unique pattern of brain activation is associated with cyberbullying and can be identified using task-based functional magnetic resonance imaging (tbfMRI). However, there is a dearth of research regarding cyberbullying and no fMRI paradigm exists in a real-time situation such as observing a cyberbullying scenario. Here, we propose a tbfMRI protocol we have developed specifically for this purpose.

This paper will describe a tbfMRI protocol that can be used to investigate the hypothesis. The overall aim of such a protocol is to elucidate the neurobiological underpinnings of cyberbullying by exploring the brain responses in passive cyber-bystanders (those who witness cyberbullying). This would be the first research to use fMRI to examine brain activation in cyberbystanders, and will bring us closer to understanding the various neurobiological underpinnings that may be associated with cybervictim/bully status and outcomes.

1. Introduction

Cyberbullying can have serious impacts on mental health (Fahy et al., 2016; Le et al., 2017; McLoughlin, Spears, & Taddeo, 2018; McLoughlin, Spears, Taddeo, & Hermens, 2019), and is commonly defined as an aggressive, repeated, intentional act carried out on an individual using electronic forms (Smith et al., 2008). Cybervictims report significantly more social difficulties, higher levels of anxiety and depression, and are more likely to suffer suicidal ideation (Kowalski, Giumetti, Schroeder, & Lattanner, 2014; van Geel, Vedder, & Tanilon, 2014) than victims of traditional bullying. Prevalence estimates vary, however, The AU Kids Online study (Green, Brady, Ólafsson, Hartley, & Lumby, 2012) found that 29% of Australian children (19% across Europe) said they had been bullied, and 13% of those bullied said this occurred on the internet.

Research on traditional bullying and its effects on the brain has primarily focused on aspects of physical aggression and offers some other important lines of enquiry with regards to the potential neurobiological aspects of cyberbullying. For example, dysfunction in the neural circuits involved in emotion processing has been linked to a propensity towards aggressive behaviour, and that such behaviour is also associated with abnormalities in the neural processes that promote both the inhibitory control of behaviour and the flexible adaptation of behaviour (Sterzer & Stadler, 2009). Other researcher indicates neural mechanisms associated with conduct disorders, antisocial behaviour, and empathy in children (Blair, 2013; van Goozen, Fairchild, Snoek, & Harold, 2007; Viding, McCrory, Blakemore, & Frederickson, 2011) and suggest that serotonergic and stress-regulating mechanisms may explain individual differences in antisocial behaviour. As such, research on neurobiological factors associated with conduct disorders have a key role to play in informing how schools manage bullying, regarding which students are most at risk of bullying behaviours and which are more likely to benefit from interventions.

Whilst limited research has specifically examining potential links between cyberbullying and adolescent brain development, emerging research by Lamblin, Murawski, Whittle, and Fornito (2017) reported

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that online social interactions are associated with similar structural correlates and patterns of brain activity to those observed in the context of real-world relationships. In other words, positive feedback online (such as "likes" on photos) is responded to similarly as interactions in face-to-face conversations (Sherman, Payton, Hernandez, Greenfield, & Dapretto, 2016). Similarly, a review on traditional bullying in young people found that the brain experiences peer victimisation (such as isolation) in a similar way to physical pain, and that these experiences can become biologically embedded in the physiology of the developing person, thereby increasing their risk of developing mental health problems (Vaillancourt, Hymel, & McDougall, 2013).

Some research suggests that there are biological markers associated with different roles in cyberbullying. Research on cyberbullying in young people aged 11 to 18 years, found that cybervictims (those only ever victimised by cyberbullying) and cyberbully-victims (those who have been both the victim and perpetrator of cyberbullying) exhibiting higher cortisol secretion levels and greater perceived stress, when compared to cyberbullies (those only ever cyberbullied others) and cyberbystanders (those witnessing cyberbullying) (González-Cabrera, Calvete, León-Mejía, Pérez-Sancho, & Peinado, 2017). More specifically, the lowest cortisol secretion was observed in cyberbullies, and cyberbullying victimisation was significantly related to an elevated profile of cortisol secretion (González-Cabrera et al., 2017).

1.1. Functional magnetic resonance imaging (fMRI), aggression and cyberbullying

fMRI is a non-invasive imaging modality that provides an indirect measurement of brain activation by quantification of the hemodynamic response to a certain stimulus (Smith, 2004). Blood oxygenation level-dependent (BOLD) task-based fMRI (tb-fMRI) has the capacity to measure hemodynamic responses to changing stimulus or task conditions with a high spatial and temporal resolution, and can detect the transient changes in deoxyhemoglobin concentration that follow the presentation of single stimuli (Boynton, Engel, Glover, & Heeger, 1996; Buckner et al., 1996; Friston et al., 1998; Smith, 2004). tb-fMRI is particularly valuable, as researchers can investigate the role and function of brain regions and how these regions respond to different conditions and stimuli, for example, witnessing cyberbullying.

Research regarding the use of fMRI and cyberbullying has mostly revolved around conduct disorder studies. Some researchers have used fMRI to further understand aggressive behaviour in 16 to 18 year-old boys (Decety, Michalska, Akitsuki, & Lahey, 2009), and found that youths with aggressive conduct disorder exhibit an atypical pattern of neural response to viewing others in pain (for example, youth with conduct disorder showed activation in the insula and precentral gyrus, whereas as control youth did not). These researchers found similar results in an earlier study regarding activity in regions of the brain in response to seeing others in pain (Decety, Michalska, & Akitsuki, 2008). Similarly, another study of 9–18 year old male and female adolescents found that callous-unemotional traits are related to variations in brain structure (grey matter volume of the bilateral anterior insular cortices), but only in males (Raschle et al., 2018).

Furthermore, Thomas, Hotsenpiller, and Peterson (2007) found that exposure to acute psychological stress (such as bullying) reduced the survival of new neurons (neurogenesis) in the hippocampus (Thomas et al., 2007). Other research suggests that aggressive behaviour might originate from an impairment of both recognition of emotional stimuli and cognitive control of emotional behaviour (Sterzer, Stadler, Krebs, Kleinschmidt, & Poustka, 2005), and that adolescents with aggressive behaviour may also have significant alterations within the emotion processing and regulation network (including orbitofrontal, dorsomedial prefrontal and limbic cortex) (Raschle, Menks, Fehlbaum, Tshomba, & Stadler, 2015).

Clearly, there is a dearth of research regarding the brain, fMRI and cyberbullying specifically, particularly in a general population sample (i.e. non-conduct disorder, non-aggressive). Little research has used real-time scenarios to measure how young people respond or react to the incident, and even less has examined how the brain responds to witnessing a cyberbullying incident. Furthermore, no research to date outlines a protocol explaining how to undertake such research, which this paper aims to do.

2. The hypothesis

The paper has the following primary hypothesis: tb-fMRI will differentiate the unique brain activation topology associated with observing a cyberbullying stimulus compared to the neutral stimulus (i.e., increased activation in the 'social brain' when observing a cyberbullying stimulus compared to the neutral stimulus: more specifically, there will be increased BOLD response in the following regions - prefrontal cortex, anterior cingulate cortex, inferior frontal gyrus, posterior superior temporal sulcus, temporoparietal junction, amygdala, and anterior insula).

Future research could elucidate the neurobiological underpinnings of cyberbullying by exploring the brain activation response (using tb-fMRI) in passive cyberbystanders. Whilst research has investigated the role of cyberbystanders, there is a paucity of research that has used real-time scenarios to measure how young people respond to cyberbullying. Furthermore, cyberbystanders are a particularly important group to understand, as they not only represent those who witness cyberbullying, but also those who have been bullies, victims and bully-victims (which can be determined via self-report), without having to constrain participants to one specific condition. In other words, rather than having participants view a scenario that is either aimed at them (as a victim) or created as though they themselves are the bully, which comes with a series of complexities, researchers can have participants observe cyberbullying as a cyberbystander, and capture these different cyberbully sub groups regardless (through self-report of their own experiences).

3. Proposed protocol

3.1. Design

3.1.1. The experimental paradigm of tb-fMRI

Scenarios of stimuli have been conceptualized and created by the authors and have been made to look as they would appear on a social networking site as follows. Furthermore, the concept for the images has been adapted from the study by Bastiaensens et al. (2014), however, they will appear as though they are images on social networking sites (with no branding of any particular site), with nuanced comments associated with them to determine their stimulus condition (negative (i.e. cyberbullying) or neutral). These scenarios have formed the Cyberbullying Picture Series (CyPicS).

The CyPicS tasks will be presented using a block designed paradigm to maximize signal-to-noise ratio (SNR) and to increase the likelihood of detecting a response. Participants will be asked to view 6 negative (cyberbullying) and 6 neutral stimuli, presented pseudo-randomly, whilst in the MRI during tb-fMRI acquisition. An example of one of the negative (cyberbullying) stimulus from the CyPicS is depicted in Fig. 1, with a neutral stimulus using the same photo depicted in Fig. 2.

Participants fMRI scans will consist of 2 different stimulus conditions. Stimuli will include a series of 6 different images (within each condition), whereby different captions will determine its condition: cyberbullying, or neutral. Each block will consist of approximately 30s activation (15 volumes) and 18 s rest (9 volumes), and each stimulus will be presented 6 times each, totaling 594 s (297 volumes). The stimuli will include 3 images depicting a female and 3 images depicting a male in each condition. This design is summarised in Fig. 3.

The CyPicS task paradigm will be run and synchronized with data acquisition via the commercially available software *E*-Prime (v2.0)

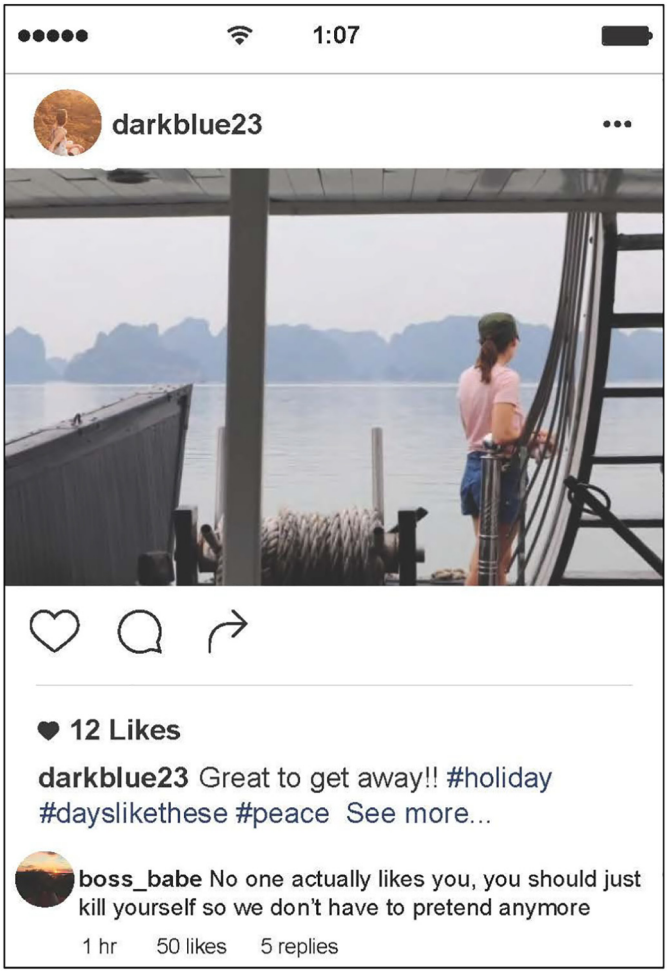

Fig. 1. Example cyberbullying scenario from CyPicS.

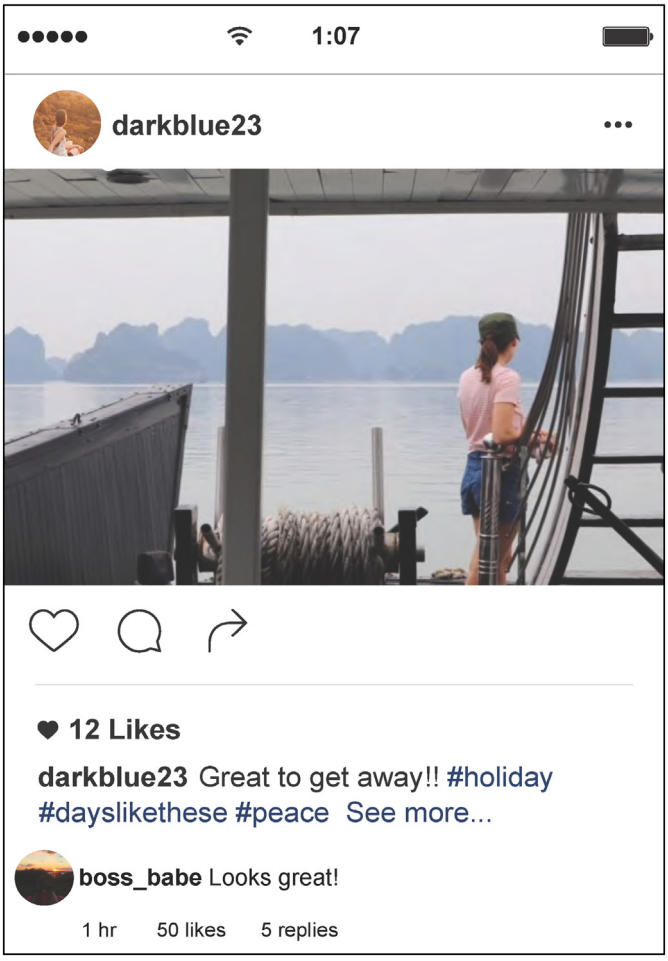

Fig. 2. Example neutral scenario from CyPicS.

(Psychology Software Tools, 2018) and fMRI plugin and visualised within the scan room on a MR compatible NordicNeuro In-roomViewingDevice (NordicNeuroLab, 2018), which will be positioned at the head of the scanner and end of the bore. A reversed mirror will be fitted to the 64-channel head coil and adjusted after the participant is centered at isocenter to ensure full view.

3.1.2. MRI collection

All scans will be conducted on a 3-Tesla Siemens Skyra MRI scanner (Germany, Erlangen) with a 64-channel head and neck coil at the Sunshine Coast Mind and Neuroscience - Thompson Institute (SCMN-TI), Nola Thompson Centre of Advanced Imaging, University of the Sunshine Coast (USC). The protocol will take 45 min: 15 min allocated for induction and preparation (i.e., completing safety checklist and changing into MRI safe gown) and 30 min for structural and tb-fMRI scans. The MRI protocol will consist of a structural, whole-brain 3D T1-weighted Magnetization-Prepared Rapid-Acquisition Gradient Echo sequence (MPRAGE; scan parameters TR = 2200 ms, TE = 1.76 ms, TI = 850 ms, FOV = 240 mm, 256 × 256 matrix, sagittal plane, spatial resolution = 0.9 mm isotropic, 208 slices and scan duration = 4 min), which will be optimised for grey/white matter contrast and used for the purpose of functional localisation. Brain activation response to the CyPicS task will be assessed using a T2*-weighted multi slice EPI sequence (TR = 2000, TE = 30, FOV = 224 mm; 74 × 74 matrix, in-plane resolution = 3 mm, IPAT6, SMS acceleration factor 3; transverse plane; slice thickness = 3 mm; 57 contiguous slices acquired top-down, 297 volumes, scan duration = 9.54 min). 18 dummy scans will be run (but no readout will be acquired) prior to the acquisition of the first TR readout. The CyPicS task will then be automatically triggered from the first "true" RF pulse of the fMRI sequence. Prior to the tb-fMRI sequence a field map with the same FOV will be acquired to aid in correcting image distortion due to field inhomogeneities.

3.2. Power analysis

A fMRI-based power analysis for identification of brain activation patterns was performed using fMRIpower software package (fmripower.org) (Mumford & Nichols, 2008). This method estimates power for detecting significant activation within specific regions of interest using pilot data of 15 subjects. The effect sizes are expressed in standard deviation (SD) units, which is analogous to the Cohens D measure. With 30 subjects a study would have 99% power to detect signal difference ranging from 0.4 to 0.8 SD of the mean signal (Cohen d of 0.4 to 0.8, medium to large effect) in different regions (from the cerebellum and occipital lobes of 0.8 to frontal and temporal lobes of 0.4).

3.3. Data analysis

Data analysis will be performed using SPM12 (Wellcome Trust Centre for Neuroimaging, London, UK). Before processing, each participant's scans will be checked for data quality; functional and structural data will be visually inspected for artifacts, coverage of brain regions, and signal dropout. The spatial preprocessing will include 2-pass motion correction and spatial normalization to the Montreal Neurological Institute (MNI) space average brain T1 template implemented in SPM12

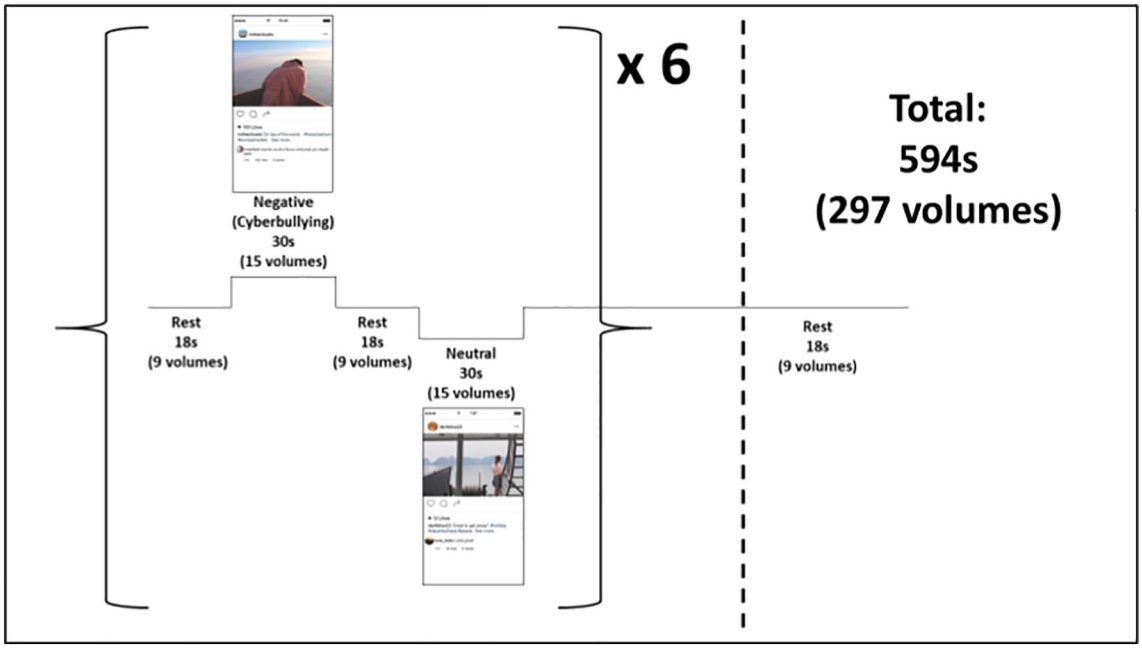

Fig. 3. Task based fMRI design.

(Ashburner & Friston, 1999). Normalized volumes will be smoothed with a 5 × 5 × 5 mm^3 full width at half maximum Gaussian kernel using SPM12.

The tfMRI data will be analysed using the two-level general linear modelling (GLM) approach implemented in SPM12. At the subject level, the activation map associated with each scenario will be determined by correlating the BOLD response with the convolution of the hemodynamic response function (HRF) and the neural events defined by the stimulus-on time and its duration. A canonical HRF with time and dispersion derivatives will be used. In the first level analysis, one statistical contrasts, cyberbullying vs. neutral scenes, will be constructed for each participant. The contrast (difference in β) images of the first-level analysis will be then used for the second-level group statistics to determine brain activation associated with cyberbullying (random effect analysis), brain response difference between groups with prior experiences versus no experience of cyber-bullying (two-sample *t*-test), and brain activations correlated with the behaviour measures (regression analysis), correcting for gender and age. The significance of clusters will be tested using family-wise error (FWE) corrected cluster *P* value ($P_{FWE} < 0.05$) with a cluster forming voxel threshold of uncorrected $P < 0.001$.

3.4. Participants

We propose that this protocol is first administered with a pilot sample of young adults (aged 18–25 years) for feasibility and ethical reasons. Next, this should be replicated in a larger sample and then the protocol should be implemented in younger cohorts, first older adolescents (aged 15–17 years), followed by younger adolescents (ages 12–15 years). A series of studies along these lines would be able to determine the replicability and utility of this cyberbullying fMRI protocol across adolescent and young adult ages.

We propose that participants be recruited from the general public, with no conditions, so that the sample can be as representative as possible. In other words, participants should not be selected based on previous cyberbullying experiences, as all participants essentially assume the role of a cyberbystander.

4. Implications for practice

This paper has highlighted the need for tbfMRI research in understanding cyberbullying. Such research will be an important contribution to existing research, and will lead to a greater understanding of how cyberbystanders may respond to different cyberbullying stimulus conditions. The proposed protocol will allow us to better understand how some cyberbystanders experience and develop difficulties concerning their mental health whilst others remain resilient in terms of their wellbeing. This proposed protocol has the scope to identify specific abnormalities that may be occurring in the brain in young adults witnessing cyberbullying. For example, this proposed protocol could identify which regions of the brain do or do not activate compared to others when witnessing cyberbullying. Fundamentally, such information will help us identify the target of early and appropriate interventions (such as education programs around respect or empathy), and may assist in understanding the behaviours of those who defend and do not defend cyberbullying actions.

Open practices statement

None of the data or materials for the experiments reported here is available, and none of the experiments was preregistered.

Declaration of competing interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

Ashburner, J., & Friston, K. J. (1999). Nonlinear spatial normalization using basis functions. *Human Brain Mapping, 7*(4), 254–266.

Bastiaensens, S., Vandebosch, H., Poels, K., Van Cleemput, K., DeSmet, A., & De Bourdeaudhuij, I. (2014). Cyberbullying on social network sites. An experimental study into bystanders' behavioural intentions to help the victim or reinforce the bully. *Computers in Human Behavior, 31*, 259–271. https://doi.org/10.1016/j.chb.2013.10.036.

Blair, R. J. (2013). The neurobiology of psychopathic traits in youths. *Nature Reviews. Neuroscience, 14*(11), 786–799. https://doi.org/10.1038/nrn3577.

Boynton, G. M., Engel, S. A., Glover, G. H., & Heeger, D. J. (1996). Linear systems analysis of functional magnetic resonance imaging in human V1. *Journal of Neuroscience,*

16(13), 4207–4221.
Buckner, R. L., Bandettini, P. A., O'Craven, K. M., Savoy, R. L., Petersen, S. E., Raichle, M. E., & Rosen, B. R. (1996). Detection of cortical activation during averaged single trials of a cognitive task using functional magnetic resonance imaging. *Proceedings of the National Academy of Sciences, 93*(25), 14878–14883.
Decety, J., Michalska, K. J., & Akitsuki, Y. (2008). Who caused the pain? An fMRI investigation of empathy and intentionality in children. *Neuropsychologia, 46*(11), 2607–2614. https://doi.org/10.1016/j.neuropsychologia.2008.05.026.
Decety, J., Michalska, K. J., Akitsuki, Y., & Lahey, B. B. (2009). Atypical empathic responses in adolescents with aggressive conduct disorder: A functional MRI investigation. *Biological Psychology, 80*(2), 203–211. https://doi.org/10.1016/j.biopsycho.2008.09.004.
Fahy, A. E., Stansfeld, S. A., Smuk, M., Smith, N. R., Cummins, S., & Clark, C. (2016). Longitudinal associations between cyberbullying involvement and adolescent mental health. *The Journal of Adolescent Health, 59*(5), 502–509. https://doi.org/10.1016/j.jadohealth.2016.06.006.
Friston, K. J., Fletcher, P., Josephs, O., Holmes, A., Rugg, M. D., & Turner, R. (1998). Event-related fMRI: characterizing differential responses. *NeuroImage, 7*(1), 30–40. https://doi.org/10.1006/nimg.1997.0306.
González-Cabrera, J., Calvete, E., León-Mejía, A., Pérez-Sancho, C., & Peinado, J. M. (2017). Relationship between cyberbullying roles, cortisol secretion and psychological stress. *Computers in Human Behavior, 70*, 153–160. https://doi.org/10.1016/j.chb.2016.12.054.
Green, L., Brady, D., Ólafsson, K., Hartley, J., & Lumby, D. (2012). Risks and safety for Australian children on the internet: Full findings from the AU kids survey of 9–16 year olds and their parents. Retrieved from www.cci.edu.au/reports/AU-Kids-Online-Survey.pdf.
Kowalski, R. M., Giumetti, G. W., Schroeder, A. N., & Lattanner, M. R. (2014). Bullying in the digital age: A critical review and meta-analysis of cyberbullying research among youth. *Psychological Bulletin, 140*(4), 1073–1137. https://doi.org/10.1037/a0035618.
Lamblin, M., Murawski, C., Whittle, S., & Fornito, A. (2017). Social connectedness, mental health and the adolescent brain. *Neuroscience and Biobehavioral Reviews, 80*, 57–68. https://doi.org/10.1016/j.neubiorev.2017.05.010.
Le, H. T., Nguyen, H. T., Campbell, M. A., Gatton, M. L., Tran, N. T., & Dunne, M. P. (2017). Longitudinal associations between bullying and mental health among adolescents in Vietnam. *International Journal of Public Health, 62*(Suppl. 1), 51–61. https://doi.org/10.1007/s00038-016-0915-8.
McLoughlin, L., Spears, B., & Taddeo, C. (2018). The importance of social connection for cybervictims: How connectedness and technology could promote mental health and wellbeing in young people. *The International Journal of Emotional Education, 10*(1), 5–24.
McLoughlin, L. T., Spears, B. A., Taddeo, C. M., & Hermens, D. F. (2019). Remaining connected in the face of cyberbullying: Why social connectedness is important for mental health. *Psychology in the Schools, 56*(6), 945–958. https://doi.org/10.1002/pits.22232.
Mumford, J. A., & Nichols, T. E. (2008). Power calculation for group fMRI studies accounting for arbitrary design and temporal autocorrelation. *NeuroImage, 39*(1), 261–268. https://doi.org/10.1016/j.neuroimage.2007.07.061.
NordicNeuroLab (2018). *Inroom viewing device.* Bergen, Norway: NordicNeuroLab.
Raschle, N. M., Menks, W. M., Fehlbaum, L. V., Steppan, M., Smaragdi, A., Gonzalez-Madruga, K., ... Stadler, C. (2018). Callous-unemotional traits and brain structure: Sex-specific effects in anterior insula of typically-developing youths. *NeuroImage: Clinical, 17*, 856–864. https://doi.org/10.1016/j.nicl.2017.12.015.
Raschle, N. M., Menks, W. M., Fehlbaum, L. V., Tshomba, E., & Stadler, C. (2015). Structural and functional alterations in right dorsomedial prefrontal and left insular cortex co-localize in adolescents with aggressive behaviour: An ALE meta-analysis. *PLoS One, 10*(9), e0136553. https://doi.org/10.1371/journal.pone.0136553.
Sherman, L. E., Payton, A. A., Hernandez, L. M., Greenfield, P. M., & Dapretto, M. (2016). The power of the like in adolescence: Effects of peer influence on neural and behavioral responses to social media. *Psychological Science, 27*(7), 1027–1035. https://doi.org/10.1177/0956797616645673.
Smith, P. K., Mahdavi, J., Carvalho, M., Fisher, S., Russell, S., & Tippett, N. (2008). Cyberbullying: Its nature and impact in secondary school pupils. *Journal of Child Psychology and Psychiatry, 49*(4), 376–385. https://doi.org/10.1111/j.1469-7610.2007.01846.x.
Smith, S. M. (2004). Overview of fMRI analysis. The British Journal of Radiology, 77 Spec No 2, S167–175. doi:https://doi.org/10.1259/bjr/33553595.
Sterzer, P., & Stadler, C. (2009). Neuroimaging of aggressive and violent behaviour in children and adolescents. *Frontiers in Behavioral Neuroscience, 3*, 35. https://doi.org/10.3389/neuro.08.035.2009.
Sterzer, P., Stadler, C., Krebs, A., Kleinschmidt, A., & Poustka, F. (2005). Abnormal neural responses to emotional visual stimuli in adolescents with conduct disorder. *Biological Psychiatry, 57*(1), 7–15. https://doi.org/10.1016/j.biopsych.2004.10.008.
Thomas, R. M., Hotsenpiller, G., & Peterson, D. A. (2007). Acute psychosocial stress reduces cell survival in adult hippocampal neurogenesis without altering proliferation. *The Journal of Neuroscience, 27*(11), 2734–2743. https://doi.org/10.1523/jneurosci.3849-06.2007.
Tools, P. S. (2018). *E-Prime.* Sharpsburg, USA: Psychology Software Tools.
Vaillancourt, T., Hymel, S., & McDougall, P. (2013). The biological underpinnings of peer victimization: Understanding why and how the effects of bullying can last a lifetime. *Theory Into Practice, 52*(4), 241–248. https://doi.org/10.1080/00405841.2013.829726.
van Geel, M., Vedder, P., & Tanilon, J. (2014). Relationship between peer victimization, cyberbullying, and suicide in children and adolescents: A meta-analysis. *JAMA Pediatrics, 168*(5), 435–442. https://doi.org/10.1001/jamapediatrics.2013.4143.
van Goozen, S. H., Fairchild, G., Snoek, H., & Harold, G. T. (2007). The evidence for a neurobiological model of childhood antisocial behavior. *Psychological Bulletin, 133*(1), 149–182. https://doi.org/10.1037/0033-2909.133.1.149.
Viding, E., McCrory, E. J., Blakemore, S.-J., & Frederickson, N. (2011). Behavioural problems and bullying at school: Can cognitive neuroscience shed new light on an old problem? *Trends in Cognitive Sciences, 15*(7), 289–291. https://doi.org/10.1016/j.tics.2011.05.001.