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## **Extremely shy & genetically close : investigating neurobiological endophenotypes of social anxiety disorder**

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### **Citation**

Bas, J. M. (2020, January 14). *Extremely shy & genetically close : investigating neurobiological endophenotypes of social anxiety disorder*. Retrieved from <https://hdl.handle.net/1887/82705>

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**Title:** Extremely shy & genetically close : investigating neurobiological endophenotypes of social anxiety disorder

**Issue Date:** 2020-01-14



## Part 3

# Functional brain characteristics as putative SAD endophenotypes





# Chapter 6

How embarrassing! The behavioral and neural correlates of processing social norm violations

Published as:

**Bas-Hoogendam, J. M.**, van Steenbergen, H., Kreuk, T., van der Wee, N. J. A., & Westenberg, P. M. (2017). How embarrassing! The behavioral and neural correlates of processing social norm violations. *PLOS ONE*, *12*, e0176326.

## ABSTRACT

Social norms are important for human social interactions, and violations of these norms are evaluated partly on the intention of the actor. Here, we describe the revised Social Norm Processing Task (SNPT-R), a paradigm enabling the study of behavioral and neural responses to intended and unintended social norm violations among both adults and adolescents. We investigated how participants (adolescents and adults,  $n = 87$ ) rate intentional and unintentional social norm violations with respect to inappropriateness and embarrassment, and we examined the brain activation patterns underlying the processing of these transgressions in an independent sample of 21 adults using functional magnetic resonance imaging (fMRI). We hypothesized to find activation within the medial prefrontal cortex, temporo-parietal cortex and orbitofrontal cortex in response to both intentional and unintentional social norm violations, with more pronounced activation for the intentional social norm violations in these regions (Berthoz, Armony, Blair, & Dolan, 2002).

Participants' ratings confirmed the hypothesis that the three types of stories are evaluated differently with respect to intentionality: intentional social norm violations were rated as the most inappropriate and most embarrassing. Furthermore, fMRI results showed that reading stories on intentional and unintentional social norm violations evoked activation within the frontal pole, the paracingulate gyrus and the superior frontal gyrus. In addition, processing unintentional social norm violations was associated with activation in, among others, the orbitofrontal cortex, middle frontal gyrus and superior parietal lobule, while reading intentional social norm violations was related to activation in the left amygdala. These regions have been previously implicated in thinking about one's self, thinking about others and moral reasoning.

Together, these findings indicate that the SNPT-R could serve as a useful paradigm for examining social norm processing, both at the behavioral and the neural level.

## INTRODUCTION

In the present work, we describe the revised Social Norm Processing Task (SNPT-R), a paradigm enabling the study of behavioral and neural responses to intended and unintended social norm violations among both adults and adolescents. More specifically, we investigated how participants rate intentional and unintentional social norm violations with respect to inappropriateness and embarrassment, and we examined the brain activation patterns underlying the processing of these transgressions.

Social norms are crucial in creating and maintaining social relationships, because they specify what is acceptable in a certain social group (Bicchieri, 2006; Cialdini & Goldstein, 2004). Transgressions of these norms induce self-conscious emotions like embarrassment and guilt (Jankowski & Takahashi, 2014; Robins & Schriber, 2009; Tangney, Stuewig, & Mashek, 2006). These emotions are prosocial, because they lead to action tendencies which are important to restore the social order (Eisenberg, 2000; Feinberg, Willer, & Keltner, 2012; Haidt, 2003).

Several studies have investigated the behavioral and neural responses to violations of norms and the associated prosocial emotions, for example while focusing on making moral judgments (Chakroff et al., 2016; Knutson et al., 2010; Schaich Borg, Hynes, Van Horn, Grafton, & Sinnott-Armstrong, 2006), the emergence of human social values (Zahn et al., 2009), the effect of the presence or absence of an audience on processing moral and social transgressions (Finger, Marsh, Kamel, Mitchell, & Blair, 2006), and the experience of self-conscious moral emotions like shame and guilt (Mclatchie, Giner-Sorolla, & Derbyshire, 2016; Michl et al., 2014; Takahashi et al., 2004). While these paradigms investigated several aspects of norm processing, the focus of the Social Norm Processing Task (SNPT), originally developed and described by Berthoz et al. (Berthoz et al., 2002; Berthoz, Grèzes, Armony, Passingham, & Dolan, 2006) and used in a subsequent study (Blair et al., 2010), is on the effect of intention on the judgment of social norm violations. The concept of ‘intentionality’ has been extensively studied (Cova, Dupoux, & Jacob, 2012; Knobe, 2003; Malle & Knobe, 1997) and the effect of the actor’s intention on the evaluation of an action has been shown previously (cf. (Chakroff et al., 2016; Knutson et al., 2010; Schaich Borg et al., 2006)). For example, intentional harmful acts were judged worse (Chakroff et al., 2016) and more ‘wrong’ (Schaich Borg et al., 2006) than accidental harmful acts.

In the SNPT, participants read and evaluate stories describing neutral social situations and situations in which social norms are intentionally or unintentionally transgressed (Berthoz et al., 2002). Social norms, in this task, are widely shared beliefs on appropriate behavior in a social situation, i.e. in a situation where others are present. It should, however, be noted that several other definitions of ‘social norms’ exist, for example in the context of economic decision games (O’Callaghan et al., 2016; Ruff, Ugazio, & Fehr, 2013; Sanfey, Stallen, & Chang, 2014; Spitzer, Fischbacher, Herrnberger, Grön, & Fehr, 2007; Yuan Zhang,

Yu, Yin, & Zhou, 2016). Furthermore, there is a debate about how social norms are different from moral norms and decency norms, a discussion which is outside the scope of this paper (Bicchieri, 2006; Brennan, Eriksson, Goodin, & Southwood, 2013; Colombo, 2014; Lisciandra, Postma-Nilsenová, & Colombo, 2013).

Results on the SNPT (Berthoz et al., 2002) revealed that participants evaluated the stories differently with respect to inappropriateness and embarrassment: healthy male participants ( $n = 12$ ) rated intentional social norm violations as more inappropriate when compared to unintentional norm violations, while they considered the unintentional norm violations as the most embarrassing (Berthoz et al., 2002, 2006). These findings indicate that the evaluation of social norm violations is determined to a great extent by the intention of the actor (Berthoz et al., 2006), given the fact that the consequences of the intentional and the unintentional social norm violations are in general the same (Berthoz et al., 2002). Furthermore, neuroimaging data on the SNPT indicated that reading stories describing intentional and unintentional social norm violations evoked activation within the medial and superior prefrontal cortex, the left temporo-parietal junction and left orbito-frontal cortex, while the intentional condition (compared to unintentional condition) was associated with stronger activation within the medial and superior frontal cortex, anterior cingulate gyrus, parietal regions including the precuneus, left superior occipital gyrus and, as shown in a re-analysis of the data, the left amygdala (Berthoz et al., 2006).

In addition to the study by Berthoz et al. on healthy male participants (Berthoz et al., 2002), the SNPT was used in an imaging study on social anxiety disorder (SAD) (Blair et al., 2010). Patients with SAD are characterized by an intense fear of negative evaluation (Stein & Stein, 2008), which was reflected by aberrant behavioral and neural responses to the SNPT. At the behavioral level, SAD patients ( $n = 16$ ) reported higher levels of inappropriateness and embarrassment across all conditions (intentional, unintentional and neutral), when compared to healthy control participants ( $n = 16$ ). Furthermore, increased activation in the medial prefrontal cortex in response to unintentional norm violations was present in SAD (Blair et al., 2010), suggesting altered self-referential processing. These findings indicate that the SNPT is a useful paradigm to investigate the neurobehavioral correlates of social anxiety, but we suggest, in line with Berthoz and colleagues (Berthoz et al., 2002), that the SNPT can also be utilized in future research on the vulnerability to other psychiatric and neurological conditions in which social behavior is typically affected.

However, previous work on the SNPT (Berthoz et al., 2002; Blair et al., 2010) has several limitations, hindering its future use. Both studies had small sample sizes ( $n = 12$  (Berthoz et al., 2002) and  $n = 16$  healthy participants (Blair et al., 2010)), and included only adult participants, while Berthoz and colleagues (2002) examined solely males. Furthermore, given the focus of these studies on the neural correlates of social norm processing, behavioral responses were not described in detail. In addition, different versions of the SNPT were used: while the SNPT employed by Blair and colleagues (2010) only comprised impersonal



stories (i.e. the story protagonist is a character like 'Joanna'), Berthoz et al. (2002, 2006) used a combination of personal and impersonal stories (i.e. the story protagonist is 'you' or the story protagonist is a character like 'Joanna', respectively), as well as 'nonsense' stories composed of unrelated words, which were not further analyzed. Furthermore, the imaging parameters of the paradigms vary to a great extent: the paradigm by Berthoz and colleagues (Berthoz et al., 2002, 2006) has a duration of more than 50 minutes, while the task used by Blair et al. lasts around 15 minutes. Finally, the stories of these SNPT-versions are not publicly available. Taken together, these differences make it hard to compare the results of these studies and to obtain a clear picture of social norm processing in healthy participants, which could serve as a reference for future studies in patients.

Here, we describe, building upon the work of Berthoz et al. (2002, 2006) and Blair et al. (2010), an adapted version of the SNPT: the revised Social Norm Processing Task (SNPT-R). In line with previous versions of the SNPT, the SNPT-R contains stories describing neutral social situations, stories on unintentional social norm violations, and stories depicting intentional social norm violations. However, in contrast to earlier versions of the SNPT (Berthoz et al., 2002, 2006; Blair et al., 2010), the SNPT-R uses only personal stories in order to maximize personal involvement of the participants while reading the stories (cf. (Finger et al., 2006)). In line with this, we developed four age- and gender specific versions of SNPT-R, making the paradigm appropriate for participants of different ages. Other changes relative to previous versions of the SNPT involve a shortening of the duration of the paradigm relative to the paradigm by Berthoz et al. (2002), mainly by omitting the 'nonsense' stories, and improvements in the fMRI design like the use of a jittered presentation of a fixation cross between the stories.

Main aim of the present study was to validate the SNPT-R, by replicating the findings of previous versions of the SNPT. First, we examined the behavioral ratings of inappropriateness and embarrassment for the three types of stories in a sample of adolescents and adults ( $n = 87$ ). We hypothesized to find an effect of intention on the evaluation of the stories, both on the ratings of inappropriateness and embarrassment, as reported previously (Berthoz et al., 2002). Secondly, we investigated neural responses to the stories using fMRI, in an independent sample of 21 adults, aiming to replicate the results described by Berthoz et al. (2002, 2006). More specifically, we expected to find activation within the medial prefrontal cortex, temporo-parietal cortex and orbitofrontal cortex in response to both intentional and unintentional social norm violations, with more pronounced activation for the intentional social norm violations in these regions (Berthoz et al., 2002). Furthermore, we hypothesized that intentional social norm violations would be associated with left amygdala activation as reported by (Berthoz et al., 2006).

The present study extends previous work on the SNPT in two ways. First, we use a larger sample of participants, including both genders and with a broader age range. Secondly, by publishing the stories used in the SNPT-R (*Supplemental Table S6.1* and [osf.io/](https://osf.io/)

pt4qt (Bas-Hoogendam, van Steenbergen, Kreuk, van der Wee, & Westenberg, 2017b)), as well as the code for stimulus presentation (available on [osf.io/pt4qt](https://osf.io/pt4qt) (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b)), and the data acquired in the present study ([osf.io/pt4qt](https://osf.io/pt4qt) (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b) and <http://neurovault.org/collections/QCZKVNWZ/>), we aim to encourage the use of the SNPT-R in future studies.

## MATERIALS AND METHODS

### Participants

One hundred eight participants were included in the study, divided into two independent samples. Sample size was determined by availability of subjects and resources. The first sample (from now on referred to as ‘behavioral sample’) consisted of adolescents and adults who performed the SNPT-R on a laptop or personal computer, while the second sample was comprised of adults who were scanned using fMRI while reading the stories (‘imaging sample’). All participants were required to have Dutch as their first language, to be in good health and to be free of past and present psychopathology as assessed by a self-report questionnaire. General contraindications for undergoing an MRI scan and left-handedness, evaluated by a self-report questionnaire, were exclusion criteria for the imaging sample.

Ninety-four participants signed up for the behavioral experiment; four participants were excluded from participation because they did not meet the selection criteria (present medication use:  $n = 3$ ; present physical disorder:  $n = 1$ ). Furthermore, data from three participants were excluded from analysis because they performed a version of the SNPT-R that did not match their age, leaving a total of 87 participants in the behavioral sample.

Twenty-three participants were screened for participation in the imaging study; one participant was excluded due to past psychopathology, one MRI session was aborted due to participant claustrophobia, resulting in a sample of 21 participants. A neuroradiologist examined all structural MRI scans; no clinically relevant abnormalities were present in any of the participants included in the imaging sample.

All participants (and in case of minors below 18 years of age, both parents) signed informed consent prior to participation. The study was approved by the Psychology Research Ethics Committee of Leiden University (behavioral sample; study numbers 2282269557 and 8070826266) and the Medical Ethical Committee of the Leiden University Medical Center (imaging sample; protocol number P12.061). Participants were recruited via flyers, in-class announcements and by word of mouth and tested between July 2013 and December 2015 (imaging sample: July - August 2013; behavioral sample adults: November - December 2014; behavioral sample adolescents: June 2015 - December 2015). After performing the experiment, participants were debriefed about the aim of the study and received a compensation

for partaking in the experiment (imaging sample: monetary reward; behavioral sample adults: study credits; behavioral sample adolescents: chocolate bar).

Sample characteristics are summarized in *Table 6.1*. Participants of the behavioral sample were divided into four groups (group 1: boys < 18 years of age; group 2: girls < 18 years of age; group 3: men  $\geq$  18 years of age; group 4: women  $\geq$  18 years of age), based on the four age- and gender specific versions of the SNPT-R. As a consequence, groups differed significantly with respect to age (oneway ANOVA:  $F(3,86) = 59.0$ ,  $p < 0.001$ ): boys and girls did not differ in age (independent-samples t-test:  $t(27) = -0.38$ , *ns*), but the men were significantly older when compared to the women ( $t(35.8) = 3.1$ ,  $p = 0.004$ ). In the imaging sample, there were no age differences between men and women ( $t(19) = 0.41$ , *ns*).

**Table 6.1** Characteristics participants.

| Behavioral sample                                       | Boys ( $n = 13$ )               | Girls ( $n = 16$ )              | Men ( $n = 29$ )                | Women ( $n = 29$ )              |
|---------------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Age in years<br><i>mean <math>\pm</math> SD (range)</i> | 14.0 $\pm$ 1.2<br>(12.7 - 16.5) | 14.2 $\pm$ 1.4<br>(12.5 - 17.0) | 21.1 $\pm$ 3.1<br>(18.5 - 32.6) | 19.2 $\pm$ 1.2<br>(18.1 - 24.1) |
| Imaging sample                                          |                                 |                                 | Men ( $n = 6$ )                 | Women ( $n = 15$ )              |
| Age in years<br><i>mean <math>\pm</math> SD (range)</i> |                                 |                                 | 25.8 $\pm$ 9.3<br>(18.7 - 44.1) | 24.0 $\pm$ 9.7<br>(18.1 - 57.1) |

**Abbreviation**

SD: standard deviation.

### Social Norm Processing Task (SNPT-R)

Participants performed the revised Social Norm Processing Task (SNPT-R), an adaptation of the Social Norm Processing Task described by (Berthoz et al., 2002, 2006; Blair et al., 2010). The SNPT-R consists of two phases: a story-reading phase and a rating phase (*Figure 6.1*). In the story-reading phase, participants read short stories written in second person. Each story consisted of two sentences, a stem sentence (duration: 3 s) and an ending sentence (duration: 6 s). The stories described either a situation in which no social norm was transgressed ('neutral condition'), a situation in which a social norm was unintentionally transgressed ('unintentional condition') or a situation in which a social norm was intentionally transgressed ('intentional condition'). It is important to note that the unintentional ('You are baking with friends. You use salt instead of sugar without realizing.') and intentional ('You are baking with friends. You use salt instead of sugar as a joke.') condition differ only in the intention of the actor, while we aimed to keep the actual outcome of the action (for example, a distasteful cake) in general the same (although the outcome of some intentional stories could be considered to be more severe in comparison to the outcome of the matching unintentional story, inherent to the verb used to describe intentionality; we refer the reader to the *Supplemental Analysis* and *Supplemental Table S6.2* for a sensitivity analysis).

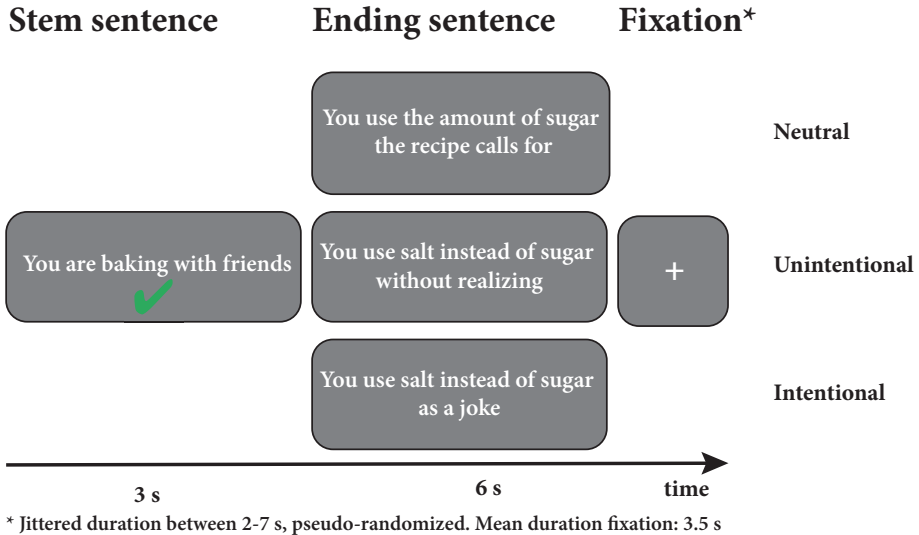
The stories in the SNPT-R were developed in collaboration with Karina S. Blair, author of previous work on the SNPT (Blair et al., 2010). All stories described everyday social

situations, in which the protagonist was accompanied by at least one other person, and the stories outlined relative innocuous violations of conventional social norms, in which no severe harm was done to others. The stories were heterogeneous with respect to the context (for example, in the presence of one friend or in public space like an airport) and the nature of the social norm transgression (for example, breaking decency rules versus hurting somebody), in order to increase the external validity of the paradigm. Stories were developed to be suitable for a broad audience and age range (for children from age 8). However, given the fact that the stories of the SNPT-R were all personal (written in 'you' form) in order to maximize personal involvement of participants, some small changes were necessary in stories describing age- or genderspecific elements. Therefore, four age- and gender specific versions of the task were developed: for boys < 18 years of age (version 1), girls < 18 years of age (version 2), men  $\geq$  18 years of age (version 3) and women  $\geq$  18 years of age (version 4). For example, the school environment (< 18 years) was replaced for a work environment ( $\geq$  18 years of age), and 'bikini bottoms' (females) for 'swimming trunks' (males). However, these changes were only minimal (see *Supplemental Table S6.1* and [osf.io/pt4qt](https://osf.io/pt4qt) for a full list of stories included in the SNPT-R (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b)).

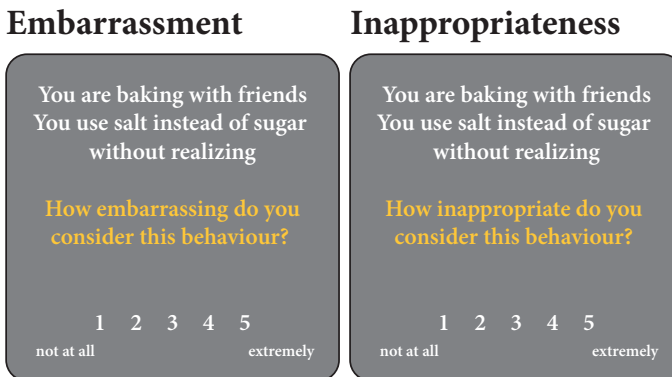
In line with the SNPT described by Blair et al. (2010), twenty-six stem sentences were developed, with three different types of ending. Therefore, the SNPT-R consisted of 78 short stories in total. These stories were presented in a pseudo-random order using E-Prime software (version 2.0.10, Psychology Software Tools; script available at [osf.io/pt4qt](https://osf.io/pt4qt) (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b)), separated by a fixation cross (jittered duration between 2 - 7 s, determined using Optseq software (<https://surfer.nmr.mgh.harvard.edu/optseq/>), mean duration fixation: 3.5 s) and divided into two consecutive blocks of 39 stories (duration each block: 8 min 44 s). Participants were instructed to imagine themselves in the social situations described and to press a button with their right index finger after reading the stem sentence of each story. A button press within 3 s resulted in visual feedback to the participant (a green checkmark presented beneath the sentence). This element was added to the paradigm in order to be able to check whether participants engaged with the task. Prior to the start of the experiment, all participants were familiarized with the story-reading phase by performing a short version of the task (using five stories).

In the (unannounced) rating phase of the task (*Figure 6.1*), participants read all stories again and were asked to rate them on a five-point Likert scale on embarrassment (ranging from 1, not embarrassing at all, to 5, extremely embarrassing) and inappropriateness (ranging from 1, not inappropriate at all, to 5, extremely inappropriate), similar as in the SNPT described by Blair and colleagues (2010). These tasks were also presented using E-Prime software (version 2.0.10, Psychology Software Tools; scripts available at [osf.io/pt4qt](https://osf.io/pt4qt) (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b)).

## 1. Story-reading phase



## 2. Rating phase



**Figure 6.1 Overview of the revised Social Norm Processing Task (SNPT-R).**

During the story-reading phase (1), participants read stories consisting of a stem sentence and an ending sentence, describing either a neutral social situation, a situation in which a social norm was unintentionally transgressed or situation in which a social norm was violated intentionally. Participants were instructed to imagine themselves in the situation described. In the rating phase (2), participants rated all stories on embarrassment and inappropriateness.

### Procedure

Participants of the behavioral sample completed both the story-reading phase as well as the rating phase of the SNPT-R on a laptop or personal computer in a quiet environment, at

the Faculty of Social and Behavioral Sciences, Leiden University (adult participants) or at a secondary school in the Netherlands (adolescent participants). After performing the SNPT-R, participants completed, depending on their age, the self-report version of the Liebowitz Social Anxiety Scale (Heimberg et al., 1999) or the Social Anxiety Scale for adolescents (La Greca & Lopez, 1998), and the Brief Fear of Negative Evaluation-R scale (Carleton et al., 2006). These results are not discussed in the present paper.

Participants of the imaging sample performed the story-reading phase of the SNPT-R in the MRI scanner, located at the Leiden University Medical Center (LUMC). Imaging data were collected during the story-reading phase using a Philips 3.0 T Achieva MRI scanner (Philips Medical Systems, Best, The Netherlands), equipped with a 32-channel SENSE (Sensitivity Encoding) head coil. During the two blocks of the story-reading phase, functional scans were acquired using T2\* weighted echo-planar imaging (repetition time (TR) = 2200 ms, echo time (TE) = 30 ms, 38 axial slices, descending acquisition, 2.75 mm × 2.75 mm × 2.75 mm + 10 % interslice gap, field of view (FOV) = 220 mm × 115 mm × 220 mm, 230 volumes/block). The first six volumes of these scans were dummy volumes and removed to allow for equilibration of T1 saturation effects. A 3D T1-weighted anatomical scan was acquired for within-subject registration purposes before the SNPT-R (TR = 9.8 ms, TE = 4.59 ms, flip angle = 8°, 140 slices, 0.875 mm × 0.875 mm × 1.2 mm, FOV = 224 mm × 168 mm × 177.333 mm). The task was part of a larger scanning session including other fMRI tasks, a resting-state scan, and a diffusion tensor imaging (DTI) scan.

Following the scan-session, participants performed the rating phase of the SNPT-R on a laptop in a quiet room next to the MRI scanner.

## Data analysis

### *Behavioral ratings*

Statistical analyses of the ratings of embarrassment and inappropriateness for the stories of the SNPT-R were performed using IBM SPSS Statistics for Windows (Version 23.0. Armonk, NY: IBM Corp.). Internal consistency of the task conditions (intentional, unintentional and neutral) was determined by calculating Cronbach's  $\alpha$  for the ratings of inappropriateness and embarrassment, and for the difference score (again both for inappropriateness and embarrassment) between the intentional and unintentional condition for each set of stories.

Repeated measures ANOVAs with condition (intentional, unintentional, neutral) as a within-subjects factor were used to investigate differences between task conditions. Furthermore, group (based on the version of the SNPT-R; group 1: boys < 18 years of age; group 2: girls < 18 years of age; group 3: men  $\geq$  18 years of age; group 4: women  $\geq$  18 years of age) was added as a between-subjects factor. The SPSS code for analysis of the behavioral data is available at [osf.io/pt4qt](https://osf.io/pt4qt) (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b). For all analyses, significance level was set at  $p \leq 0.05$  and Greenhouse–Geisser correction was used when the assumption of sphericity was violated.

### *Imaging data*

Analysis of fMRI data was performed using FEAT (FMRI Expert Analysis Tool; version 6.00) (Jenkinson, Beckmann, Behrens, Woolrich, & Smith, 2012; Smith et al., 2004), (FSL, RRID:SCR\_002823; scripts available at [osf.io/pt4qt](https://osf.io/pt4qt) (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b)). Prestatistics processing consisted of motion correction using MCFLIRT (Jenkinson, Bannister, Brady, & Smith, 2002), non-brain removal using BET (Smith, 2002), spatial smoothing using a Gaussian kernel of full-width half-maximum (FWHM) 6.0 mm, grand-mean intensity normalization of the entire 4D dataset by a single scaling factor in order to enable higher-level analyses, and high-pass temporal filtering (Gaussian-weighted least-squares straight line fitting, with  $\sigma = 30.0$  s). Functional scans of each participant were registered to the individual 3D T1-weighted anatomical scan using FLIRT (Jenkinson et al., 2002; Jenkinson & Smith, 2001) and subsequently registered to the Montreal Neurological Institute (MNI) T1-template brain (resolution 2 mm) using FNIRT nonlinear registration (Andersson et al., 2007). Next, event-related statistical analysis of the time-series was carried out in native space using FILM with local autocorrelation correction (Woolrich, Ripley, Brady, & Smith, 2001). For each participant, four explanatory variables (EVs) with their temporal derivatives were included in the general linear model, representing the presentation of 1<sup>st</sup> a stem sentence, 2<sup>nd</sup> a neutral ending sentence, 3<sup>rd</sup> an unintentional norm violation ending and 4<sup>th</sup> an intentional norm violation ending. Onset of the EVs was determined using custom-written scripts in Matlab (Mathworks; code available at [osf.io/pt4qt](https://osf.io/pt4qt) (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b)). The stem EV had a duration of 3 s, the ending EVs had a duration of 6 s. EVs were convolved with a double gamma hemodynamic response function. In addition, nuisance regressors were included for time-points corresponding to motion outliers using the FSL motion outliers program (<http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/FSLMotionOutliers>), which defined outlier time-points using the 75<sup>th</sup> percentile plus 1.5 times the InterQuartileRange criterion. The mean number of excluded time-points for block 1 and 2 of the story-reading phase of the SNPT-R was 12.00 (range: 1 - 24 volumes) and 13.24 (range: 3 - 26 volumes), corresponding to respectively 5.2% and 5.8% of the volumes for each block.

Subsequently, four contrasts of interest were defined, following the contrasts described by Berthoz et al. (2002): 1<sup>st</sup> intentional norm violation endings > neutral endings; 2<sup>nd</sup> unintentional norm violation endings > neutral endings; 3<sup>rd</sup> intentional norm violation endings > unintentional norm violation endings; 4<sup>th</sup> unintentional norm violation endings > intentional norm violation endings. We verified whether the individual scans were registered correctly and confirmed that relative motion parameters did not exceed 2.5 mm. Subsequently, the individual contrast images of the two story-reading blocks of the SNPT-R were combined using a within-subject multi-session fixed-effects analysis and the resulting contrast images were submitted to higher-level mixed-effects group analyses using FM-RIB's Local Analysis of Mixed Effects (FLAME-1) (Beckmann, Jenkinson, & Smith, 2003;

Woolrich, 2008; Woolrich, Behrens, Beckmann, Jenkinson, & Smith, 2004). We performed whole-brain analyses to investigate clusters related to the four contrasts of interest and tested clusters for significance using a height threshold of  $z > 2.3$  and a cluster-corrected significance threshold of  $p < 0.05$ , using Gaussian random field theory (Worsley, 2001). In addition, we determined, in line with the analysis described by Berthoz et al. (2002), common areas activated by the intentional and unintentional norm violations by applying a binary mask of the areas significantly activated by contrast 2 (unintentional norm violation endings > neutral endings) to contrast 1 (intentional norm violation endings > neutral endings), again using the above-mentioned statistical thresholds.

Furthermore, we investigated, following Berthoz and colleagues (2006) who re-analyzed the data of Berthoz et al. (2002) to test the hypothesis that the amygdala is pivotal in processing one's own intentional social norm transgressions, a hypothesis which was confirmed, activation within the left amygdala for the contrasts involving intentional norm violations. Therefore, we used a mask that was created in standard space (resolution  $2 \times 2 \times 2$  mm) using the Harvard-Oxford Subcortical Structural Atlas implemented in FSLView (version 3.2.0), which included voxels with a probability of at least 50 % of belonging to the left amygdala. Again, a height threshold of  $z > 2.3$  and a cluster-corrected significance threshold of  $p < 0.05$  was used.

Unthresholded statistical maps have been uploaded to NeuroVault.org (Gorgolewski et al., 2015) and are available at <http://neurovault.org/collections/QCZKVNWZ/> as well as at [osf.io/pt4qt](https://osf.io/pt4qt) (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b).

## RESULTS

### Behavioral ratings

#### *Task characteristics*

The items of the SNPT-R for each condition were shown to have good internal consistency with respect to the ratings of both embarrassment (intentional: Cronbach's  $\alpha = 0.94$ ; unintentional: Cronbach's  $\alpha = 0.90$ ; neutral: Cronbach's  $\alpha = 0.73$ ) and inappropriateness (intentional: Cronbach's  $\alpha = 0.85$ ; unintentional: Cronbach's  $\alpha = 0.88$ ; neutral: Cronbach's  $\alpha = 0.66$ ). Furthermore, Cronbach's  $\alpha$  on the difference scores (intentional vs. unintentional) was high (embarrassment: Cronbach's  $\alpha = 0.90$ ; inappropriateness: Cronbach's  $\alpha = 0.84$ ), indicating that the stories were internally consistent with respect to the difference between the intentional and unintentional condition.

#### *Differences between task conditions and effects of group (behavioral sample)*

Ratings for the three task conditions of the SNPT-R (behavioral sample) are presented in Table 6.2 and Figure 6.2 (for ratings at individual and story level, we refer the reader to



**Table 6.2 Ratings of inappropriateness and embarrassment for the SNPT-R stories – behavioral sample.**

|                       | Inappropriateness  |                      |                | Embarrassment      |                      |                |
|-----------------------|--------------------|----------------------|----------------|--------------------|----------------------|----------------|
|                       | <i>Intentional</i> | <i>Unintentional</i> | <i>Neutral</i> | <i>Intentional</i> | <i>Unintentional</i> | <i>Neutral</i> |
| Total sample          | 4.43 ± 0.36        | 2.93 ± 0.51          | 1.29 ± 0.20    | 3.83 ± 0.67        | 3.50 ± 0.56          | 1.25 ± 0.21    |
| <i>Boys (n = 13)</i>  | 4.01 ± 0.40        | 2.71 ± 0.48          | 1.25 ± 0.21    | 3.49 ± 0.59        | 3.19 ± 0.63          | 1.27 ± 0.22    |
| <i>Girls (n = 16)</i> | 4.43 ± 0.34        | 2.94 ± 0.41          | 1.24 ± 0.17    | 3.75 ± 0.62        | 3.36 ± 0.45          | 1.23 ± 0.12    |
| <i>Men (n = 29)</i>   | 4.44 ± 0.33        | 3.03 ± 0.48          | 1.29 ± 0.19    | 3.76 ± 0.62        | 3.35 ± 0.52          | 1.20 ± 0.20    |
| <i>Women (n = 29)</i> | 4.60 ± 0.23        | 2.92 ± 0.58          | 1.33 ± 0.21    | 4.09 ± 0.72        | 3.87 ± 0.44          | 1.31 ± 0.23    |

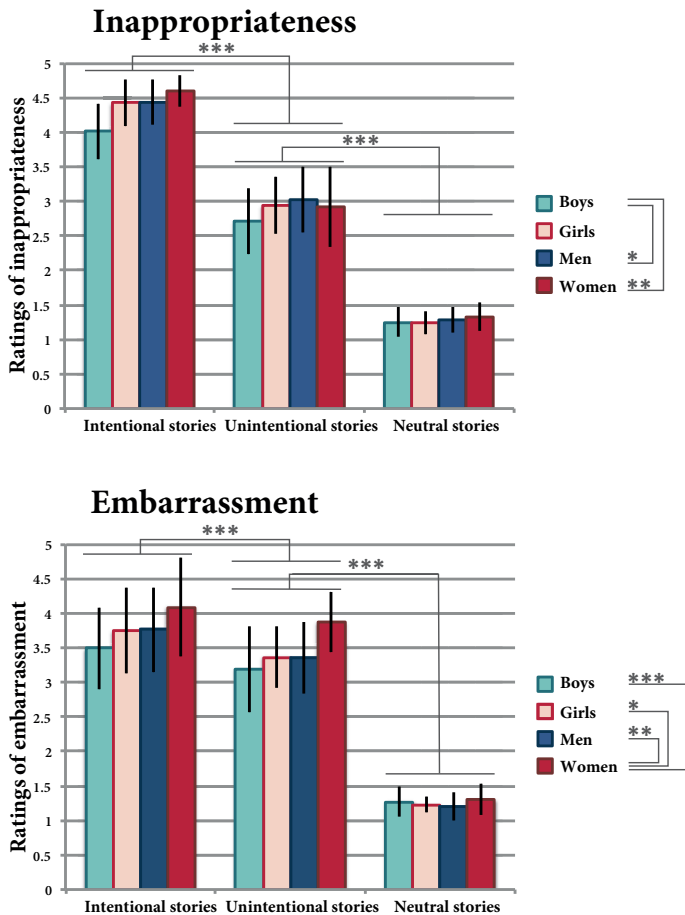
**Footnote**

Values represent mean ± standard deviation.

*Supplemental Table S6.3*; original E-Prime output files and csv files are also available at [osf.io/pt4qt](https://osf.io/pt4qt) (Bas-Hoogendam, van Steenberg, Kreuk, et al., 2017b)). Given the unequal sample sizes, we checked whether the variances were significantly different between the groups. This was not the case: for both the embarrassment and inappropriateness data, Box's Test of Equality of Covariance Matrices was not significant (inappropriateness: Box's  $M = 20.7$ ,  $F(18, 10272.5) = 1.1$ ,  $p = 0.38$ ; embarrassment: Box's  $M = 17.4$ ,  $F(18, 10272.5) = 0.89$ ,  $p = 0.59$ ). Furthermore, Levene's Test of Equality of Error Variance was not significant (inappropriateness intentional:  $F(3,83) = 2.14$ ,  $p = 0.10$ ; inappropriateness unintentional:  $F(3,83) = 1.01$ ,  $p = 0.39$ ; inappropriateness neutral:  $F(3,83) = 0.49$ ,  $p = 0.69$ ; embarrassment intentional:  $F(3,83) = 0.50$ ,  $p = 0.69$ ; embarrassment unintentional  $F(3,83) = 1.40$ ,  $p = 0.25$ ; embarrassment neutral:  $F(3,83) = 1.13$ ,  $p = 0.34$ ), indicating that the assumptions for interpreting the results of the repeated measures ANOVA are met.

Repeated measures ANOVAs (condition x group) showed significant effects of condition on both the ratings of embarrassment ( $F(1.7,144.4) = 790.8$ ,  $p < 0.001$ ,  $\eta^2 = 0.90$ ) and inappropriateness ( $F(1.7,137.1) = 2018.5$ ,  $p < 0.001$ ,  $\eta^2 = 0.96$ ). In addition, there were significant effects of group on the ratings of embarrassment ( $F(3,83) = 7.02$ ,  $p < 0.001$ ,  $\eta^2 = 0.20$ ) and ratings of inappropriateness ( $F(3,83) = 3.9$ ,  $p = 0.011$ ,  $\eta^2 = 0.12$ ), as well as interaction effects between group and condition (embarrassment:  $F(5.2,144.4) = 2.5$ ,  $p = 0.03$ ,  $\eta^2 = 0.009$ ; inappropriateness:  $F(5.0,137.1) = 3.0$ ,  $p = 0.01$ ,  $\eta^2 = 0.004$ ) (*Figure 6.2*).

Post-hoc paired-samples t-tests showed that the mean ratings of inappropriateness were significantly higher for the intentional stories relative to the unintentional stories ( $t(86) = 27.7$ ,  $p < 0.001$ ,  $r = 0.95$ ), while the unintentional stories were rated as more inappropriate compared to the neutral stories ( $t(86) = 34.0$ ,  $p < 0.001$ ,  $r = 0.96$ ). A similar pattern was found for the ratings of embarrassment: participants rated the intentional stories as the most embarrassing (intentional > unintentional:  $t(86) = 4.6$ ,  $p < 0.001$ ,  $r = 0.44$ ), and the unintentional stories as more embarrassing when compared to the neutral stories ( $t(86) = 40.3$ ,  $p < 0.001$ ,  $r = 0.97$ ). Separate repeated measures ANOVAs for each group confirmed that the effect of condition was significant for all age- and gender specific versions of the task, both for inappropriateness and embarrassment (effect of condition on inappropriateness:



**Figure 6.2 Behavioral ratings on the SNPT-R ( $n = 87$ , behavioral sample).**

Stories describing intentional social norm violations were rated as more inappropriate and more embarrassing when compared to stories on unintentional social norm violations, while unintentional stories were considered more inappropriate and more embarrassing in comparison to neutral stories. Boys rated the stories as less inappropriate when compared to men and women; women rated the stories as more embarrassing in comparison to the other groups. Data are presented as means  $\pm$  SD.

\*:  $p \leq 0.05$ ; \*\*:  $p \leq 0.01$ ; \*\*\*:  $p \leq 0.001$ .

boys:  $F(2,24) = 255.0$ ,  $p < 0.001$ ,  $\eta^2 = 0.96$ ; girls:  $F(2,30) = 627.8$ ,  $p < 0.001$ ,  $\eta^2 = 0.98$ ; men:  $F(2,56) = 709.8$ ,  $p < 0.001$ ,  $\eta^2 = 0.96$ ; women:  $F(1.4,39.3) = 845.8$ ,  $p < 0.001$ ,  $\eta^2 = 0.97$ ; effect of condition on embarrassment: boys:  $F(2,24) = 99.2$ ,  $p < 0.001$ ,  $\eta^2 = 0.89$ ; girls:  $F(2,30) = 146.9$ ,  $p < 0.001$ ,  $\eta^2 = 0.91$ ; men:  $F(2,56) = 356.0$ ,  $p < 0.001$ ,  $\eta^2 = 0.93$ ; women:  $F(1.5,42.3) = 351.8$ ,  $p < 0.001$ ,  $\eta^2 = 0.93$ ).

Post-hoc tests (corrected for multiple comparisons using Bonferroni correction) indicated that boys rated the stories as less inappropriate when compared to men ( $p = 0.03$ ) and

women ( $p = 0.01$ ), while a follow-up oneway ANOVA showed that this effect was specific for the intentional condition ( $F(3,86) = 10.6$ ,  $p < 0.001$ ,  $\eta^2 = 0.28$ ), with significant differences between boys and the other groups (Bonferroni-corrected comparisons: boys < girls,  $p = 0.003$ ; boys < men:  $p = 0.001$ ; boys < women:  $p < 0.001$ ). There were no group differences with respect to the ratings of inappropriateness for the unintentional ( $F(3,86) = 1.2$ , *ns*) and neutral stories ( $F(3,86) = 0.9$ , *ns*).

Women rated the stories overall as more embarrassing in comparison to boys ( $p = 0.001$ ), girls ( $p = 0.03$ ) and men ( $p = 0.003$ ), and a follow-up oneway ANOVA indicated that this effect was present in the intentional ( $F(3,86) = 2.9$ ,  $p = 0.04$ ,  $\eta^2 = 0.10$ ; women > boys,  $p = 0.04$ ) and the unintentional condition ( $F(3,86) = 8.2$ ,  $p < 0.001$ ,  $\eta^2 = 0.23$ ; women > boys:  $p = 0.001$ ; women > girls:  $p = 0.009$ ; women > men:  $p = 0.001$ ; all comparisons Bonferroni-corrected for multiple comparisons). There were no differences between the groups with respect to the embarrassment-ratings of the neutral condition ( $F(3,86) = 1.7$ , *ns*).

### ***Differences between task conditions and effects of group (imaging sample)***

Ratings for the three task conditions of the SNPT-R (imaging sample) are presented in Table 6.3 (for ratings at individual and story level, we refer the reader to *Supplemental Table 6.4*; original E-Prime output files and csv files are also available at [osf.io/pt4qt](https://osf.io/pt4qt) (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b)). Repeated measures ANOVAs replicated all significant effects found in the behavioral sample. That is, there was a significant effect of condition for both the ratings of embarrassment ( $F(2,38) = 216.1$ ,  $p < 0.001$ ,  $\eta^2 = 0.91$ ) and inappropriateness ( $F(1.5,28.2) = 271.0$ ,  $p < 0.001$ ,  $\eta^2 = 0.92$ ), with the highest ratings of embarrassment and inappropriateness for the intentional stories (embarrassment: intentional > unintentional:  $t(20) = 3.9$ ,  $p = 0.001$ ,  $r = 0.66$ ; unintentional > neutral:  $t(20) = 17.3$ ,  $p = 0.001$ ,  $r = 0.97$ ; inappropriateness: intentional > unintentional:  $t(20) = 17.9$ ,  $p < 0.001$ ,  $r = 0.97$ ; unintentional > neutral:  $t(20) = 12.0$ ,  $p < 0.001$ ,  $r = 0.94$ ). Furthermore, there were significant effects of group on the ratings of embarrassment and inappropriateness (embarrassment:  $F(1,19) = 5.8$ ,  $p = 0.03$ ,  $\eta^2 = 0.23$ ; inappropriateness:  $F(1,19) = 4.7$ ,  $p = 0.04$ ,  $\eta^2 = 0.20$ ), with higher ratings for women compared to men. In addition, results showed a significant interaction between condition and group on the ratings of inappropriateness ( $F(1.5, 28.2) = 4.4$ ,  $p = 0.03$ ,  $\eta^2 = 0.01$ ), while this interaction was significant at trend level for the ratings of embarrassment ( $F(2,38) = 3.0$ ,  $p = 0.06$ ,  $\eta^2 = 0.01$ ). Oneway ANOVAs indicated that women rated intentional social norm violations as more inappropriate relative to men ( $F(1,20) = 5.4$ ,  $p = 0.03$ ,  $\eta^2 = 0.22$ ), and unintentional social norm violations as both more inappropriate ( $F(1,20) = 5.7$ ,  $p = 0.03$ ,  $\eta^2 = 0.23$ ) and more embarrassing ( $F(1,20) = 7.6$ ,  $p = 0.01$ ,  $\eta^2 = 0.29$ ). The other comparisons were not significant (embarrassment intentional:  $F(1,20) = 3.3$ , *ns*; embarrassment neutral:  $F(1,20) = 0.25$ , *ns*; inappropriateness neutral:  $F(1,20) = 0.14$ , *ns*).

**Table 6.3 Ratings of inappropriateness and embarrassment for the SNPT-R – imaging sample.**

|                       | Inappropriateness  |                      |                | Embarrassment      |                      |                |
|-----------------------|--------------------|----------------------|----------------|--------------------|----------------------|----------------|
|                       | <i>Intentional</i> | <i>Unintentional</i> | <i>Neutral</i> | <i>Intentional</i> | <i>Unintentional</i> | <i>Neutral</i> |
| Total sample          | 4.37 ± 0.49        | 3.11 ± 0.60          | 1.40 ± 0.32    | 4.00 ± 0.62        | 3.53 ± 0.60          | 1.33 ± 0.27    |
| <i>Men (n = 6)</i>    | 4.01 ± 0.71        | 2.66 ± 0.77          | 1.44 ± 0.57    | 3.64 ± 0.60        | 3.03 ± 0.72          | 1.28 ± 0.34    |
| <i>Women (n = 15)</i> | 4.51 ± 0.30        | 3.28 ± 0.44          | 1.38 ± 0.18    | 4.16 ± 0.59        | 3.73 ± 0.43          | 1.35 ± 0.24    |

**Footnote**

Values represent mean ± standard deviation.

**Imaging data*****Behavioral responses during story-reading phase***

We verified whether participants engaged with the task during the story-reading phase by examining the behavioral responses of the participants (i.e. a button press during the presentation of the stem sentence). On average, participants responded to 96 % of trials (number of missed responses / block of 39 trials (mean ± SD): 1.6 ± 1.8, range 0 - 8), indicating good task compliance.

***Intentional norm violations versus neutral stories***

Reading stories describing intentional social norm violations evoked activation in a cluster encompassing the paracingulate gyrus, superior frontal gyrus and frontal pole, extending into the left inferior frontal gyrus, frontal operculum cortex and left caudate ( $p = 0.01$ ; cluster-size 748 voxels; peak coordinate in MNI space (x, y, z): -10, 28, 36; peak z-value = 3.39), when compared to reading neutral stories (Table 6.4; Figure 6.3A). Furthermore, significant activation was present in the left amygdala, revealed by a post-hoc analysis using a mask of the left amygdala ( $p = 0.033$ ; cluster-size 21 voxels; peak coordinate in MNI space (x, y, z): -18, -10, -12; peak z-value = 3.15).

***Unintentional norm violations versus neutral stories***

Reading stories describing unintentional social norm violations evoked activation in a cluster including the left superior frontal gyrus, left middle frontal gyrus, left frontal pole, left paracingulate gyrus and right superior frontal gyrus ( $p < 0.001$ ; cluster-size 1604 voxels; peak coordinate in MNI space (x, y, z): -14, 52, 14; peak z-value = 3.99), when compared to reading neutral stories (Table 6.4; Figure 6.3B).

***Intentional versus unintentional norm violations***

There were no clusters where reading the intentional norm violations evoked more activation when compared to reading the unintentional norm violations (using a height threshold of  $z > 2.3$  and a cluster-corrected significance threshold of  $p < 0.05$ ). Even when we restricted the analysis to the regions reported in (Berthoz et al., 2002), using a region

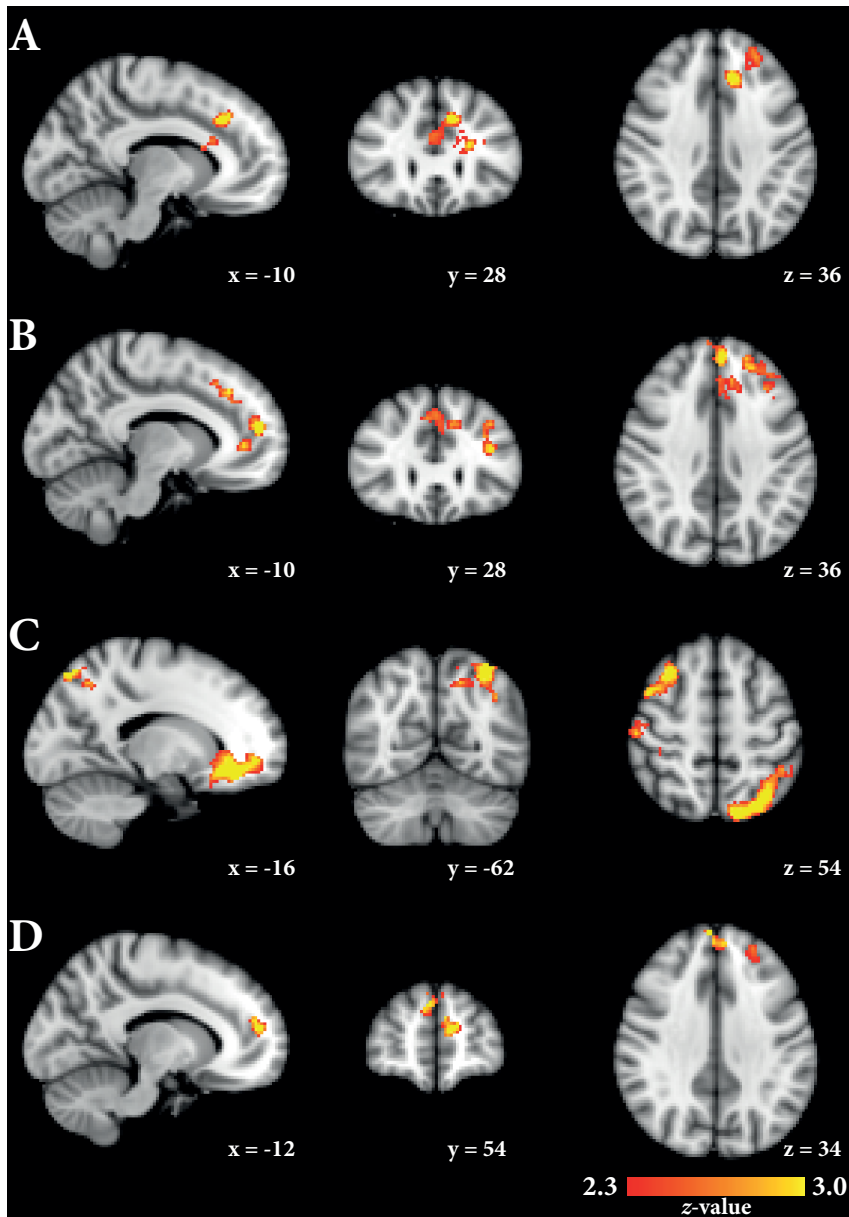
of interest approach (spheres with a radius of 5 mm around the coordinates reported for the contrast intentional > unintentional transgressions) and applied a liberal threshold ( $p < 0.05$ , uncorrected), no significant activation was found. Furthermore, no activation was present in the left amygdala.

### ***Unintentional versus intentional norm violations***

Comparison of brain activation related to reading the unintentional norm violations versus intentional norm violations revealed three clusters (Table 6.4; Figure 6.3C). The first cluster contained the left orbitofrontal cortex, left paracingulate gyrus and subcallosal cortex, and extended into the right frontal medial cortex ( $p < 0.001$ ; cluster-size 2179 voxels; peak coordinate in MNI space (x, y, z): -26, 36, -14; peak z-value = 4.39). The second cluster encompassed the right postcentral gyrus and right middle frontal gyrus ( $p = 0.002$ ; cluster-size 982 voxels; peak coordinate in MNI space (x, y, z): 38, -36, 66; peak z-value = 3.42), the third cluster was located in the left lateral occipital cortex and the left superior parietal lobule ( $p = 0.003$ ; cluster-size 926 voxels; peak coordinate in MNI space (x, y, z): -34, -64, 58; peak z-value = 3.80).

### ***Overlap between intentional and unintentional norm violations***

In line with the work of Berthoz and colleagues (2002), we also examined common areas activated by the intentional and unintentional norm violations. We created a binary mask of the significant activation cluster of contrast 2 (unintentional norm violation endings > neutral endings) and investigated activation related to contrast 1 (intentional norm violation endings > neutral endings) within this mask. We found three clusters of common activation (Table 6.4; Figure 6.3D): a cluster encompassing left and right superior frontal gyrus ( $p = 0.02$ ; cluster-size 167 voxels; peak coordinate in MNI space (x, y, z): 4, 56, 34; peak z-value = 3.43), a cluster in the left paracingulate gyrus extending into the left superior frontal gyrus ( $p = 0.02$ ; cluster-size 150 voxels; peak coordinate in MNI space (x, y, z): -12, 52, 16; peak z-value = 3.23) and a cluster in the left frontal pole ( $p = 0.05$ ; cluster-size 98 voxels; peak coordinate in MNI space (x, y, z): -26, 40, 40; peak z-value = 2.99).



**Figure 6.3** Significant activation clusters related to processing stories describing social norm violations.

*Figure 6.3A* Contrast intentional > neutral;

*Figure 6.3B* Contrast unintentional > neutral;

*Figure 6.3C* Contrast unintentional > intentional;

*Figure 6.3D* Overlap intentional & unintentional.

Clusters are superimposed on the template MNI\_T1\_152\_2mm\_brain (partial brain coverage; inferior parts of the frontal medial cortex and superior parts of the postcentral gyrus are not included). All images are displayed according to radiological convention: right in image is left in brain.

**Table 6.4. Brain activity related to reading social stories describing intentional and unintentional norm violations versus neutral situations.**

| Cluster                                                      | Region                                            | Z-score | Peak coordinates<br>(MNI space) |     |     | Cluster<br>size |
|--------------------------------------------------------------|---------------------------------------------------|---------|---------------------------------|-----|-----|-----------------|
|                                                              |                                                   |         | x                               | y   | z   |                 |
| <b>Intentional norm violations vs neutral stories</b>        |                                                   |         |                                 |     |     |                 |
| 1                                                            | Left paracingulate gyrus / superior frontal gyrus | 3.39    | -10                             | 28  | 36  | 748             |
|                                                              | Left frontal pole                                 | 2.99    | -26                             | 40  | 40  |                 |
|                                                              | Left frontal operculum cortex                     | 2.87    | -44                             | 12  | 6   |                 |
|                                                              | Left amygdala*                                    | 3.15    | -18                             | -10 | -12 | 21              |
| <b>Unintentional norm violations vs neutral stories</b>      |                                                   |         |                                 |     |     |                 |
| 1                                                            | Left paracingulate gyrus / superior frontal gyrus | 3.99    | -14                             | 52  | 14  | 1604            |
|                                                              | Left superior frontal gyrus                       | 3.72    | -4                              | 46  | 38  |                 |
|                                                              | Left middle frontal gyrus                         | 3.46    | -36                             | 30  | 20  |                 |
|                                                              | Right superior frontal gyrus                      | 3.46    | 8                               | 52  | 28  |                 |
|                                                              | Left frontal pole                                 | 3.39    | -20                             | 42  | 32  |                 |
| <b>Intentional versus unintentional norm violations</b>      |                                                   |         |                                 |     |     |                 |
| <i>No significant clusters</i>                               |                                                   |         |                                 |     |     |                 |
| <b>Unintentional versus intentional norm violations</b>      |                                                   |         |                                 |     |     |                 |
| 1                                                            | Left orbitofrontal cortex                         | 4.39    | -26                             | 36  | -14 | 2179            |
|                                                              | Left paracingulate gyrus                          | 3.52    | -10                             | 48  | -6  |                 |
|                                                              | Right frontal medial cortex                       | 3.52    | 2                               | 52  | -8  |                 |
|                                                              | Subcallosal cortex                                | 3.46    | 2                               | 26  | -8  |                 |
| 2                                                            | Right postcentral gyrus                           | 3.42    | 38                              | -36 | 66  | 982             |
|                                                              | Right middle frontal gyrus                        | 3.30    | 32                              | 20  | 54  |                 |
| 3                                                            | Left lateral occipital cortex                     | 3.80    | -34                             | -64 | 58  | 926             |
|                                                              | Left superior parietal lobule                     | 3.36    | -36                             | -58 | 48  |                 |
| <b>Overlap unintentional and intentional norm violations</b> |                                                   |         |                                 |     |     |                 |
| 1                                                            | Right superior frontal gyrus                      | 3.43    | 4                               | 56  | 34  | 167             |
|                                                              | Left superior frontal gyrus                       | 3.15    | -6                              | 50  | 36  |                 |
| 2                                                            | Left paracingulate gyrus                          | 3.23    | -12                             | 52  | 16  | 150             |
|                                                              | Left superior frontal gyrus                       | 2.98    | -6                              | 54  | 22  |                 |
| 3                                                            | Left frontal pole                                 | 2.99    | -26                             | 40  | 40  | 98              |

**Footnote**

\*: post-hoc analysis using mask of left amygdala.

## DISCUSSION

In the present study, we investigated the behavioral and neural correlates of social norm processing in two independent samples, using a new instrument: the revised Social Norm Processing Task (SNPT-R). The SNPT-R, based on a task originally developed by Berthoz and colleagues (2002, 2006) and used by Blair et al. (2010), entails three conditions, allowing the investigation of the neural responses and behavioral ratings related to processing 1<sup>st</sup> stories describing intentional violations of social norms, 2<sup>nd</sup> stories on unintentional violations of social norms, and 3<sup>rd</sup> neutral social stories (*Figure 6.1*), in both adolescents and adults. We examined the behavioral ratings of the stories (concerning inappropriateness and embarrassment) in a sample of adolescents and adults ( $n = 87$ ), and examined both the behavioral as well as the neural correlates of social norm processing using functional magnetic resonance imaging (fMRI) in an independent sample of 21 adults. Our overall aim was to replicate the results from previous versions of the SNPT (Berthoz et al., 2002, 2006; Blair et al., 2010) and to describe the characteristics of the SNPT-R in detail, in order to enable the use of this paradigm in future studies involving both healthy participants and patient populations. Findings are discussed below.

### **Ratings of embarrassment and inappropriateness: dependent on type of story**

In a large sample of adolescents and adults, we examined the ratings of inappropriateness and embarrassment concerning the three types of stories. Because all stories were written in second person ('you') and participants were asked to imagine themselves in the situation described, the ratings reflect how participants evaluate their own social norm transgressions. Results indicated a consistent effect of condition: participants rated the stories describing intentional social norm violations as the most inappropriate and the most embarrassing, while the unintentional social norm transgressions were rated more inappropriate and more embarrassing than the neutral stories (*Table 6.2; Figure 6.2*). These effects of condition were confirmed in the behavioral ratings by another, independent sample ( $n = 21$ ) of adults (*Table 6.3*). Again, intentional social norm violations were rated as more inappropriate and more embarrassing than unintentional social norm violations. It is important to mention that we aimed to keep the actual outcomes of the intentional and unintentional social norm transgressions as far as possible the same. Thereby, these results indicate that participants consider their intention of importance for the evaluation of the transgression. The higher levels of inappropriateness for the intentional social norm violations indicate that participants are familiar with social conventions, while we hypothesize that the higher levels of embarrassment for the intentional social norm violations indicate that participants 1<sup>st</sup> realize that intentional actions decrease their personal reputation to a greater extent than unintentional actions (Moll & Schulkin, 2009), and 2<sup>nd</sup> that they are aware that intentional social norm violations require more prosocial behavior (i.e. by communicating to others



that they recognize and regret their misbehavior and that they will do better in the future, as defined by Miller (2007)) than unintentional social norm violations.

Our finding with respect to the pattern of inappropriateness ratings is in line with the results of Berthoz and colleagues, demonstrating that healthy males ( $n = 12$ ) rated intentional norm violations as more inappropriate than unintentional norm violations (Berthoz et al., 2002). However, the ratings of embarrassment reported here do not coincide with those described in Berthoz et al. (2002), who found that mean embarrassment ratings were significantly higher for the unintentional social norm violations than for the intentional social norm violations. Nevertheless, our results seem to be in line with the behavioral ratings on embarrassment by healthy participants ( $n = 16$ ) in the study by Blair et al. (2010), showing slightly higher ratings of embarrassment for intentional than for unintentional social norm violations - although this study did not statistically test within-group differences between the task conditions. These discrepancies stress the need for replication studies.

It is important to note that the SNPT-R differs from previous versions of the paradigm (Berthoz et al., 2002, 2006; Blair et al., 2010) in the sense that the SNPT-R includes four age- and gender specific versions: for boys < 18 years of age, girls < 18 years of age, men  $\geq$  18 years of age and women  $\geq$  18 years of age. These versions were created in order to maximize the personal involvement of participants with the task, which was important because we aimed to investigate the behavioral and neural responses involved in evaluating one's own actions (cf. (Finger et al., 2006)). We investigated whether the effect of condition on inappropriateness and embarrassment was present in all participant groups. Results showed that this was indeed the case, indicating that all four versions of the SNPT-R enable distinguishing intentional and unintentional social norm violations based on behavioral ratings of inappropriateness and embarrassment. We did find, however, differences between the groups: boys considered the stories as less inappropriate when compared to the adult groups (both men and women), while women reported higher levels of embarrassment when rating the stories (in comparison to all other groups; *Figure 6.2*). We hypothesize that these effects are due to gender differences and developmental changes in moral sensitivity (Jennings, Mitchell, & Hannah, 2015; Krettenauer, Colasante, Buchmann, & Malti, 2014; You, Maeda, & Bebeau, 2011), but future research is needed to examine this in detail.

### **Processing stories on social norm violations: overlapping and differential activation patterns for intentional and unintentional violations**

Imaging results showed that reading stories describing social norm violations (both intentional and unintentional) evoked overlapping activation within the frontal pole, the paracingulate gyrus, and the superior frontal gyrus, relative to reading neutral social stories (*Table 6.4; Figure 6.3*). Furthermore, we observed activation within the middle frontal gyrus related to reading unintentional social norm violations when compared to reading neutral stories, while reading intentional social norm violations (in comparison to reading neutral

stories) evoked activation within the frontal pole, paracingulate gyrus and frontal operculum cortex. In addition, reading stories on intentional social norm transgressions was related to activation in the left amygdala. When contrasting unintentional and intentional norm violations, differential activation was found within three clusters: a cluster encompassing the left orbitofrontal cortex, frontal medial cortex and subcallosal cortex, a cluster involving the right postcentral gyrus and right middle frontal gyrus, and an occipital-parietal cluster (Table 6.4; Figure 6.3). There were no clusters where reading the intentional norm violations evoked more activation in comparison to the unintentional norm violations.

These results are largely in line with the findings of Berthoz and colleagues (2002), who investigated the neural systems underlying the processing of social norm transgressions in a sample of twelve healthy male participants; they reported activation in several regions in the medial prefrontal cortex in response to social norm violations, as well as in the orbitofrontal cortex, temporo-parietal regions and the basal temporal cortex. Furthermore, a re-analysis of the same dataset revealed enhanced activation in the left amygdala in response to intentional social norm violations, a finding that was replicated in the present study. In addition, our findings coincide with the results of neuroimaging studies considering brain activation related to thinking about the self and thinking about others, and of studies on moral reasoning – processes which are important in evaluating social norm violations (Denny, Kober, Wager, & Ochsner, 2012; Finger et al., 2006; Gallagher & Frith, 2003; Michl et al., 2014; Moll, de Oliveira-Souza, Bramati, & Grafman, 2002; Northoff et al., 2006; Schaich Borg et al., 2006; Takahashi et al., 2004). More specifically, the paracingulate gyrus and superior frontal gyrus, activated by both intentional and unintentional social norm violations, have been implicated previously in mentalizing (Gallagher & Frith, 2003) and the experience of shame (Michl et al., 2014), embarrassment (Takahashi et al., 2004) and guilt (Morey et al., 2012), while activation within the frontal pole is associated with moral reasoning (Schaich Borg et al., 2006). Furthermore, the ventral medial frontal cortex and orbitofrontal cortex, in this study activated by unintentional social norm violations, were found to be involved in self-related judgements (Denny et al., 2012), self-referential processing (Northoff et al., 2006), moral emotions (Moll, de Oliveira-Souza, Eslinger, et al., 2002; Moll, de Oliveira-Souza, Bramati, et al., 2002) and in evaluative processes of embarrassment (Takahashi et al., 2004). Our results build upon these findings and provide more insight in the neural processes underlying dealing with one's own social norm transgressions.

It should, however, be noted that we did not find significant clusters when contrasting intentional versus unintentional social norm violations, while Berthoz et al. (2002) reported more pronounced activation in several prefrontal, temporal and parietal regions when investigating this contrast. This discrepancy is possibly due to differences in task parameters (the task employed by Berthoz and colleagues involved both personal and impersonal stories, as well as stories comprised of 'unrelated words' (Berthoz et al., 2002, 2006), while the SNPT-R only involved personal stories written in second-person), and the use of a

more stringent statistical threshold in the present study. In addition, we cannot exclude the possibility that the participants' initial reaction to the stories, while reading them in the MRI scanner, differs from the reaction as reflected in the ratings after the scan session. These ratings indicated higher levels of embarrassment and inappropriateness for the stories on intentional social norm violations, but it is possible that unintentional transgressions evoked more arousal on the first time reading, which is reflected in increased activation levels in the brain. However, data to test this hypothesis are not available.

### **Limitations and suggestions for future research**

In line with previous work on the SNPT (Berthoz et al., 2002; Blair et al., 2010), we focused on the experience of embarrassment in relation to social norm violations. However, given the fact that social norm violations could also evoke other reactions, future studies could investigate how participants rate the stories with respect to the experience of other prosocial emotions like shame and guilt (Jankowski & Takahashi, 2014; Robins & Schriber, 2009; Tangney et al., 2006), as well as look into the potential positive outcomes of social norm transgressions for the transgressor (van Kleef, Wanders, Stamkou, & Homan, 2015).

A limitation of the present study is the relatively small sample size of the adolescent sample (13 boys and 16 girls). However, the distribution of the variances was not significantly different between the groups and the effect of condition on behavioral ratings was robustly present in all samples (all  $p < 0.001$ , both for ratings of inappropriateness and embarrassment), so we feel our data provide substantial support for the usefulness of the SNPT-R in these populations.

Another shortcoming is the fact that we did not acquire imaging data in the adolescent sample. As a result, we were not able to investigate developmental changes in brain activation related to social norm processing. Given the fact that adolescence is a time period characterized by influential changes in social-affective and social cognitive abilities (Crone & Dahl, 2012; Haller et al., 2015), it could be hypothesized that reading one's own social norm violations evokes differential activation patterns in adolescents in comparison to adults. Future studies, in line with the behavioral study by Lahat and colleagues (Lahat, Helwig, & Zelazo, 2012), could investigate this topic.

Furthermore, based on the results of Blair et al. (2010), showing aberrant behavioral and neural responses to social norm violations in patients with SAD, and given the fact that social anxiety symptoms are present at a continuum, ranging from a total lack of symptoms to normal levels of social anxiety or even mild social fears, in the normal population (Rapee & Spence, 2004), future studies could investigate the relation between self-report measures of social anxiety and behavioral ratings of social norm violations in healthy participants. In addition, we suggest that the SNPT-R could be used to investigate the behavioral and neural correlates of social norm processing in other patient populations in which disturbances of social behavior are present, for example in patients with frontal brain lesions, patients with

frontotemporal dementia and patients with personality disorders. Using the SNPT-R across disorders is in line with the Research Domain Criteria project (RDoC), which proposes a framework for conducting research in which core symptoms (in this case: disturbances in social behavior) are studied at different levels and across diagnostic classifications of disorders, in order to gain more insight in the mechanisms underlying normal and abnormal behavior (Insel, 2014).

## CONCLUSIONS

To conclude, the data presented here provide support for the use of the SNPT-R to investigate the behavioral and neural substrates of social norm processing. Intentional social norm violations were rated as more inappropriate and more embarrassing when compared to unintentional social norm violations, while reading stories describing these violations evoked activation within the frontal pole, the paracingulate gyrus and the superior frontal gyrus. Furthermore, processing unintentional social norm violations was associated with activation in, among others, the orbitofrontal cortex, middle frontal gyrus and superior parietal lobule, while reading intentional social norm violations was related to activation in the left amygdala. These regions have been previously implicated in thinking about one's self, thinking about others and moral reasoning. These findings indicate that the SNPT-R could serve as a useful paradigm for examining social norm processing, both at the behavioral and neural level.

## SUPPLEMENTAL ANALYSIS

### Sensitivity analysis on outcome stories

We aimed to keep the actual outcome of the action described in the intentional condition the same as the outcome of the action described in the unintentional condition. However, as the editor pointed out in his comments on a previous version of this manuscript, the phrasing of the stories differs between the intentional and unintentional condition. In some stories, we only varied words like ‘purposefully’ and ‘by accident’, in other stories we used a different verb that in itself explained whether the action was intentional or unintentional. We chose to do so to make the paradigm more lively (we thought that only varying the words ‘purposefully’ and ‘by accident’ would make the task monotonous), and more realistic. However, these differences in phrasing could have induced differences in how participants considered the outcomes of the actions, which could have subsequently influenced their ratings of inappropriateness and embarrassment.

We performed a sensitivity analysis to investigate whether these phrasing differences between the stories could have systematically influenced our results. First, we determined for each story whether the outcome of the intentional action could be considered different (more severe) relative to the effect of the action described in the unintentional condition. This seems to be the case for ten stories (*Supplemental Table S6.2*); for these stories, it is uncertain whether research participants consider the effects of the intentional and unintentional condition the same.

Second, to investigate the extent to which these stories might have influenced the embarrassment and inappropriateness ratings, we performed a sensitivity-analysis by excluding these stories. Repeated measures ANOVAs (condition-by-group) on the remaining 16 stories showed the same effects as reported for the full set of stories: we found significant effects of condition on both the ratings of embarrassment ( $F(1.7,143.8) = 643.44, p < 0.001$ ) and inappropriateness ( $F(1.8,150.8) = 1740.5, p < 0.001$ ). Post-hoc paired-samples t-tests confirmed that the mean ratings of inappropriateness were significantly higher for the intentional stories relative to the unintentional stories ( $t(86) = 25.5, p < 0.001$ ), while the unintentional stories were rated as more inappropriate compared to the neutral stories ( $t(86) = 33.0, p < 0.001$ ). Furthermore, intentional stories were rated as more embarrassing than the unintentional stories ( $t(86) = 2.7, p = 0.007$ ), while unintentional stories were more embarrassing relative to neutral stories ( $t(86) = 38.4, p < 0.001$ ).

In our opinion, these findings indicate that the overall effect that we have reported in the manuscript does not depend on the stories in which the outcome of the intentional and the unintentional action could be considered to be different.

## SUPPLEMENTAL TABLES



Supplemental Figure S6.1 QR code for easy access to Supplemental Table S6.1.

**Supplemental Table S6.1 Full list of SNPT-R stories.**

Stories are available in Dutch, as used in the LFLSAD, and in English.

Furthermore, stories are available for download at the Open Science Framework Database (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b). <https://osf.io/pt4qt/files/> - Methods – SNPT-R stories

|   | Dutch                                                                                                                                            | English                                                                                                              |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| 1 | Je wilt een ritje in de achtbaan maken                                                                                                           | You want to take a ride on the roller coaster                                                                        |
|   | <i>Intentional</i> Je ziet de lange rij en dringt voor                                                                                           | You see the long queue, and push in at the front of the line                                                         |
|   | <i>Unintentional</i> Je ziet de lange rij niet en gaat vooraan staan                                                                             | You don't see the long queue, and go and stand at the front                                                          |
|   | <i>Neutral</i> Je ziet de lange rij en sluit achteraan                                                                                           | You see the long queue, and go and stand at the end                                                                  |
| 2 | Je loopt op het strand                                                                                                                           | You are walking on the beach                                                                                         |
|   | <i>Intentional</i> Je ziet een zonnende vrouw liggen en schopt tegen haar been                                                                   | You see a woman sunbathing and kick her leg                                                                          |
|   | <i>Unintentional</i> Je ziet een zonnende vrouw niet liggen en struikelt over haar been                                                          | You don't notice a woman sunbathing and accidentally trip over her leg                                               |
|   | <i>Neutral</i> Je ziet een zonnende vrouw liggen en loopt om haar heen                                                                           | You see a woman sunbathing and step around her                                                                       |
| 3 | Je hebt een glas cola in je hand (jongens/meisjes);<br>Je hebt een glas wijn in je hand (mannen/vrouwen)                                         | You are holding a glass of coke (boys/girls);<br>You are holding a glass of wine (men/women)                         |
|   | <i>Intentional</i> Je loopt naar een vriend en gooit cola (wijn) over hem heen                                                                   | You walk over to a friend and throw the coke (wine) on him                                                           |
|   | <i>Unintentional</i> Je struikelt en morst cola (wijn) over een vriend                                                                           | You stumble and spill coke (wine) on a friend                                                                        |
|   | <i>Neutral</i> Je drinkt de cola (wijn) samen met een vriend op                                                                                  | You and your friend finish the glass of coke (wine)                                                                  |
| 4 | Je vouwt in de pauze een papieren vliegtuigje (jongens/meisjes)<br>Je vouwt een papieren vliegtuigje terwijl je op je werk bent (mannen/vrouwen) | During break, you make a paper airplane (boys/girls)<br>While you are at work, you make a paper airplane (men/women) |
|   | <i>Intentional</i> Je gooit het vliegtuigje naar je leraar (collega) en het raakt zijn hoofd                                                     | You throw the airplane at your teacher (colleague) and the airplane hits his head                                    |
|   | <i>Unintentional</i> Je gooit het vliegtuigje naar een open raam maar het raakt het hoofd van je leraar (collega)                                | You throw the airplane at the open window, but the airplane hits your teacher (colleague) on the head                |
|   | <i>Neutral</i> Je gooit het vliegtuigje door het open raam naar buiten                                                                           | You aim the airplane at the open window, and the airplane flies through the window                                   |
| 5 | Je gaat naar de wc                                                                                                                               | You go to the toilet                                                                                                 |
|   | <i>Intentional</i> Je ziet dat er iemand op zit, maar trekt de deur open                                                                         | You see that it's occupied but you open the door                                                                     |
|   | <i>Unintentional</i> Je ziet niet dat er iemand op zit en doet de deur open                                                                      | You don't see that it's occupied and you open the door                                                               |

|    | Dutch                                                                                                                                          | English                                                                                                                  |
|----|------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
|    | <i>Neutral</i> Je ziet dat er iemand op zit en wacht voor de deur                                                                              | You see that it's occupied and wait in front of the door                                                                 |
| 6  | Je krijgt een zelfgebakken koekje van een vriendin                                                                                             | You receive a cookie your friend baked                                                                                   |
|    | <i>Intentional</i> Je vindt het koekje vies en spuugt het uit                                                                                  | You dislike it and spit it out                                                                                           |
|    | <i>Unintentional</i> Je verslikt je in het koekje en spuugt het uit                                                                            | You take a bite of the cookie, choke, and spit it out                                                                    |
|    | <i>Neutral</i> Je neemt een hap en eet het koekje op                                                                                           | You take a bite of the cookie, chew, and swallow it                                                                      |
| 7  | Je bent op een feestje                                                                                                                         | You are at a party                                                                                                       |
|    | <i>Intentional</i> Je gooit je drankje over een andere gast                                                                                    | You throw your drink over another guest                                                                                  |
|    | <i>Unintentional</i> Je struikelt en morst je drankje over een andere gast                                                                     | You trip, and spill your drink over another guest                                                                        |
|    | <i>Neutral</i> Je geeft je drankje aan een andere gast                                                                                         | You give your drink to another guest                                                                                     |
| 8  | Je staat op een balkon boven een drukke stoep                                                                                                  | You are standing on a balcony above a busy street                                                                        |
|    | <i>Intentional</i> Je ziet een vrouw en spuugt op haar hoofd                                                                                   | You see a woman below and spit on her head                                                                               |
|    | <i>Unintentional</i> Je spuugt en raakt per ongeluk een vrouw op haar hoofd                                                                    | You spit and hit a woman by accident                                                                                     |
|    | <i>Neutral</i> Je spuugt naar beneden en raakt een lege plek op de stoep                                                                       | You see an empty patch below, spit and hit the ground                                                                    |
| 9  | Je gaat bij je oma eten (jongens/meisjes);<br>Je gaat bij je schoonmoeder eten (mannen/vrouwen)                                                | You go to your grandmother's house for dinner (boys/girls);<br>You go to your mother-in-law's for dinner (men/women)     |
|    | <i>Intentional</i> Je vindt het eten niet lekker en spuugt het uit                                                                             | You do not like the food and spit it out                                                                                 |
|    | <i>Unintentional</i> Je voelt je helemaal niet lekker en moet overgeven                                                                        | You feel unwell and vomit over the table                                                                                 |
|    | <i>Neutral</i> Je vindt het eten lekker en eet het op                                                                                          | You like the food and eat it all                                                                                         |
| 10 | Je zit in de klas en moet heel nodig naar de wc (jongens/meisjes);<br>Je zit in een vergadering en moet heel nodig naar de wc (mannen/vrouwen) | You are in the classroom and really need to pee (boys/girls);<br>You are in a meeting and really need to pee (men/women) |
|    | <i>Intentional</i> Je wilt het niet ophouden en plast op de grond                                                                              | You don't want to hold it in and pee on the floor in front of everyone                                                   |
|    | <i>Unintentional</i> Je kan het niet ophouden en plast in je broek                                                                             | You can't hold it in and wet yourself in front of everyone                                                               |
|    | <i>Neutral</i> Je kan het ophouden en gaat na de les naar de wc                                                                                | You hang on until the end of the meeting and go to the toilet afterwards                                                 |
| 11 | Je komt door de regen kletsnat aan op school (jongens/meisjes);<br>Je komt door de regen kletsnat aan op je werk (mannen/vrouwen)              | You get soaked on the way to school (boys/girls);<br>You get soaked on the way to the office (men/women)                 |



|    | Dutch                                                                                                                                                                                    | English                                                                                                                                                                  |
|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | <i>Intentional</i> Je kleedt je uit waar iedereen bij is om droge kleren aan te trekken                                                                                                  | You undress in front of everyone in order to change clothes                                                                                                              |
|    | <i>Unintentional</i> Je trekt je natte kleren uit en dan komen opeens klasgenoten (collega's) aanlopen                                                                                   | You undress, but suddenly classmates (colleagues) walk in on you                                                                                                         |
|    | <i>Neutral</i> Je gaat naar je werkplek en laat je kleren opdrogen                                                                                                                       | You sit down at your desk and wait to get dry                                                                                                                            |
| 12 | Je drinkt een glas cola bij de lunch op school (jongens/meisjes);<br>Je drinkt een glas cola bij de lunch op je werk                                                                     | You drink a glass of coke for lunch at school (boys/girls);<br>You drink a glass of coke for lunch at the office (men/women)                                             |
|    | <i>Intentional</i> Je ziet je leraar (baas) en laat expres een harde boer                                                                                                                | You see your teacher (boss) and burp in front of him                                                                                                                     |
|    | <i>Unintentional</i> Je ziet je leraar (baas) niet en laat per ongeluk een harde boer                                                                                                    | You don't see your teacher (boss), and burp in front of him                                                                                                              |
|    | <i>Neutral</i> Je ziet je leraar (baas) en kan een boer nog net inhouden                                                                                                                 | You see your teacher (boss) and are able to swallow the burp                                                                                                             |
| 13 | Je bent op het vliegveld en moet naar de wc                                                                                                                                              | You need to go to the toilet at the airport                                                                                                                              |
|    | <i>Intentional</i> Je ziet een damestoilet maar je gaat toch naar binnen (jongens/mannen);<br>Je ziet een herentoilet maar je gaat toch naar binnen (meisjes/vrouwen)                    | You notice the sign on the wall but go into the women's toilet anyway (boys/men);<br>You notice the sign on the wall but go into the men's toilet anyway (girls/women)   |
|    | <i>Unintentional</i> Je ziet niet dat het een damestoilet is en je gaat naar binnen (jongens/mannen);<br>Je ziet niet dat het een herentoilet is en je gaat naar binnen (jongens/mannen) | You don't see the sign on the wall and go into the women's toilet (boys/men);<br>You don't see the sign on the wall and go into the men's toilet (girls/women)           |
|    | <i>Neutral</i> Je ziet het damestoilet en zoekt dan naar het herentoilet (jongens/mannen);<br>Je ziet het herentoilet en zoekt dan naar het damestoilet (meisjes/vrouwen)                | You see the sign of the women's toilet and look for the men's toilet (boys/men);<br>You see the sign of the women's toilet and look for the women's toilet (girls/women) |
| 14 | Je bent in het zwembad                                                                                                                                                                   | You are at the swimming pool                                                                                                                                             |
|    | <i>Intentional</i> Je duikt in het water en trekt je zwembroek uit (jongens/mannen);<br>Je duikt in het water en trekt je bikinibroekje uit (meisjes/vrouwen)                            | You dive in the water and take off your swimming trunks (boys/men);<br>You dive in the water and take off your bikini bottoms (girls/women)                              |
|    | <i>Unintentional</i> Je duikt in het water en je zwembroek (bikinibroekje) zakt af                                                                                                       | You dive in the water and your swimming trunks (bikini bottoms) fall off                                                                                                 |
|    | <i>Neutral</i> Je duikt in het water en trekt je zwembroek (bikinibroekje) weer goed                                                                                                     | You dive in the water and adjust your swimming trunks (bikini bottoms)                                                                                                   |
| 15 | Je bent in de klas aan het lezen (jongens/meisjes);<br>Je bent op je kantoor met collega's (mannen/vrouwen)                                                                              | You and your class are quietly reading (boys/girls);<br>You are at the office with your colleagues (men/women)                                                           |
|    | <i>Intentional</i> Je laat expres een harde wind                                                                                                                                         | You decide to fart loudly                                                                                                                                                |
|    | <i>Unintentional</i> Je laat per ongeluk een harde wind                                                                                                                                  | You accidentally fart loudly                                                                                                                                             |

|    | Dutch                                                                                                                                                                     | English                                                                                                                           |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
|    | <i>Neutral</i> Je moet een wind laten maar houdt het tegen                                                                                                                | You have to fart but you can hold it in                                                                                           |
| 16 | Je speelt voetbal                                                                                                                                                         | You are playing football                                                                                                          |
|    | <i>Intentional</i> Je schiet expres de bal in je eigen doel                                                                                                               | You purposefully kick the ball in your own team's goal                                                                            |
|    | <i>Unintentional</i> Je schiet per ongeluk de bal in je eigen doel                                                                                                        | You accidentally kick the ball in your own team's goal                                                                            |
|    | <i>Neutral</i> Je schiet de bal in het doel van de tegenstander                                                                                                           | You purposefully kick the ball in the other team's goal                                                                           |
| 17 | Op bezoek bij familie begint je neus te lopen                                                                                                                             | While visiting family, your nose starts to run                                                                                    |
|    | <i>Intentional</i> Je veegt je neus af aan het tafellaken                                                                                                                 | You wipe your nose on the table cloth                                                                                             |
|    | <i>Unintentional</i> Je neus drupt per ongeluk op het tafellaken                                                                                                          | Your nose drips by accident on the table cloth                                                                                    |
|    | <i>Neutral</i> Je snuit je neus in een zakdoekje                                                                                                                          | You wipe your nose in a tissue                                                                                                    |
| 18 | Je bakt een appeltaart samen met vrienden                                                                                                                                 | You are baking an apple pie with your friends                                                                                     |
|    | <i>Intentional</i> Voor de grap gebruik je zout in plaats van suiker                                                                                                      | You use salt instead of sugar as a joke                                                                                           |
|    | <i>Unintentional</i> Je vergist je en gebruikt zout in plaats van suiker                                                                                                  | You use salt instead of sugar without realizing                                                                                   |
|    | <i>Neutral</i> Je gebruikt de juiste hoeveelheid suiker                                                                                                                   | You use the amount of sugar the recipe calls for                                                                                  |
| 19 | Je hebt met een vriend afgesproken om een computerspelletje te spelen (jongens/meisjes);<br>Je hebt met een vriend afgesproken om koffie te gaan drinken (mannen/vrouwen) | You've arranged to meet a friend to play a computer game (boys/girls);<br>You've arranged to meet a friend for coffee (men/women) |
|    | <i>Intentional</i> Je besluit om weg te blijven                                                                                                                           | You decide not to turn up                                                                                                         |
|    | <i>Unintentional</i> Je vergeet de afspraak                                                                                                                               | You forget to go                                                                                                                  |
|    | <i>Neutral</i> Je gaat naar de afspraak                                                                                                                                   | You go and meet your friend                                                                                                       |
| 20 | Je past op de hamster van de burens                                                                                                                                       | You are petsitting for your neighbour                                                                                             |
|    | <i>Intentional</i> Je besluit de hamster niet te voeren en de hamster gaat dood                                                                                           | You decide not to feed the hamster, and it dies                                                                                   |
|    | <i>Unintentional</i> Je vergeet de hamster te voeren en de hamster gaat dood                                                                                              | You forget to feed the hamster, and it dies                                                                                       |
|    | <i>Neutral</i> Je voedt de hamster totdat de burens weer terug zijn                                                                                                       | You feed the hamster until the neighbour's return                                                                                 |
| 21 | Je verft het haar van een vriend (jongens/mannen);<br>Je verft het haar van een vriendin (meisjes/vrouwen)                                                                | You are dyeing your friend's hair                                                                                                 |
|    | <i>Intentional</i> Je verft het haar expres blauw                                                                                                                         | You purposefully dye it blue                                                                                                      |

|    | Dutch                                                                                                                                                              | English                                                                                                                      |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
|    | <i>Unintentional</i> Er gaat iets mis en het haar wordt blauw                                                                                                      | You mess up and her hair becomes blue                                                                                        |
|    | <i>Neutral</i> Zoals afgesproken verf je het haar blauw                                                                                                            | You dye it blue as planned                                                                                                   |
| 22 | Je bent aan de telefoon met een vriend (jongens/mannen); Je bent aan de telefoon met een vriendin (meisjes/vrouwen)                                                | You are on the phone with a friend                                                                                           |
|    | <i>Intentional</i> Je vindt het gesprek niet interessant en je hangt op zonder gedag te zeggen                                                                     | You feel bored with the conversation and hang up without saying goodbye                                                      |
|    | <i>Unintentional</i> De telefoon glijdt uit je hand en de verbinding wordt verbroken                                                                               | The telephone slips out of your hand and the connection is lost                                                              |
|    | <i>Neutral</i> Na gedag te zeggen zet je de telefoon uit                                                                                                           | After saying goodbye you hang up                                                                                             |
| 23 | Je zit in de bus naast een onbekende man                                                                                                                           | You are on the bus next to a stranger                                                                                        |
|    | <i>Intentional</i> Je leunt tegen de schouder van je buurman en gaat slapen                                                                                        | You decide to sleep and lean on your neighbour's shoulder                                                                    |
|    | <i>Unintentional</i> Je valt in slaap tegen de schouder van je buurman                                                                                             | You fall asleep, slumped against your neighbour's shoulder                                                                   |
|    | <i>Neutral</i> Je valt in slaap tegen het raam                                                                                                                     | You fall asleep leaning against the window                                                                                   |
| 24 | Je bent in de klas (jongens/meisjes);<br>Je bent aan het werk (mannen/vrouwen)                                                                                     | You are in your classroom (boys/girls);<br>You are at the office (men/women)                                                 |
|    | <i>Intentional</i> Je ziet de leraar (je baas) aankomen en gooit de deur voor zijn neus dicht                                                                      | You see your teacher (boss) coming and you slam the door in his face                                                         |
|    | <i>Unintentional</i> Je ziet de leraar (je baas) niet aankomen en doet de deur vlak voor hem dicht                                                                 | You don't see your teacher (boss) coming and you shut the door right in front of him                                         |
|    | <i>Neutral</i> Je ziet de leraar (je baas) aankomen en houdt de deur voor hem open                                                                                 | You see your teacher (boss) coming and you hold the door open for him                                                        |
| 25 | Je bent erg verkouden                                                                                                                                              | You have a cold                                                                                                              |
|    | <i>Intentional</i> Voor de lol nies je in het gezicht van een klasgenoot (jongens/meisjes);<br>Voor de lol nies je in het gezicht van een collega (mannen/vrouwen) | You sneeze in your classmate's face for a laugh (boys/girls);<br>You sneeze in your colleague's face for a laugh (men/women) |
|    | <i>Unintentional</i> Je moet ineens niezen en niest in het gezicht van een klasgenoot (collega)                                                                    | All of a sudden you have to sneeze and you sneeze in a classmate's (colleague's) face                                        |
|    | <i>Neutral</i> Je moet niezen en houdt je hand voor je mond                                                                                                        | You have to sneeze and you cover your mouth with your hand                                                                   |
| 26 | Je laat de hond uit                                                                                                                                                | You are walking the dog                                                                                                      |
|    | <i>Intentional</i> Je ziet dat de hond op straat poept maar je loopt door                                                                                          | You see the dog defecating on the street but you keep walking                                                                |
|    | <i>Unintentional</i> Je ziet niet dat de hond op straat poept en je loopt door                                                                                     | You don't see the dog defecating on the street and you keep walking                                                          |
|    | <i>Neutral</i> Je ziet dat de hond op straat poept en je ruimt het op                                                                                              | You see the dog defecating on the street and you clean it up                                                                 |

**Supplemental Table S6.2 Comparison of outcome *SNPT-R* stories (sensitivity analysis).**

|    | <b>Intentional</b>                                                      | <b>Unintentional</b>                                                                      | <b>Outcome same severity?</b> |
|----|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------|
| 1  | You see the long queue, and push in at the front of the line            | You don't see the long queue, and go and stand at the front                               | Questionable                  |
| 2  | You see a woman sunbathing and kick her leg                             | You don't notice a woman sunbathing and accidentally trip over her leg                    | Questionable                  |
| 3  | You walk over to a friend and throw the coke on him                     | You stumble and spill coke on a friend                                                    | Questionable                  |
| 4  | You throw the airplane at your teacher and the airplane hits his head   | You throw the airplane at the open window, but the airplane hits your teacher on the head | Yes                           |
| 5  | You see that it's occupied but you open the door                        | You don't see that it's occupied and you open the door                                    | Questionable                  |
| 6  | You dislike it and spit it out                                          | You take a bite of the cookie, choke, and spit it out                                     | Yes                           |
| 7  | You throw your drink over another guest                                 | You trip, and spill your drink over another guest                                         | Questionable                  |
| 8  | You see a woman below and spit on her head                              | You spit and hit a woman by accident                                                      | Yes                           |
| 9  | You do not like the food and spit it out                                | You feel unwell and vomit over the table                                                  | Questionable                  |
| 10 | You don't want to hold it in and pee on the floor in front of everyone  | You can't hold it in and wet yourself in front of everyone                                | Questionable                  |
| 11 | You undress in front of everyone in order to change clothes             | You undress, but suddenly classmates walk in on you                                       | Yes                           |
| 12 | You see your teacher and burp in front of him                           | You don't see your teacher, and burp in front of him                                      | Yes                           |
| 13 | You notice the sign on the wall but go into the women's toilet anyway   | You don't see the sign on the wall and go into the women's toilet                         | Yes                           |
| 14 | You dive in the water and take off your swimming trunks                 | You dive in the water and your swimming trunks fall off                                   | Yes                           |
| 15 | You decide to fart loudly                                               | You accidentally fart loudly                                                              | Yes                           |
| 16 | You purposefully kick the ball in your own team's goal                  | You accidentally kick the ball in your own team's goal                                    | Yes                           |
| 17 | You wipe your nose on the table cloth                                   | Your nose drips by accident on the table cloth                                            | Questionable                  |
| 18 | You use salt instead of sugar as a joke                                 | You use salt instead of sugar without realizing                                           | Yes                           |
| 19 | You decide not to turn up                                               | You forget to go                                                                          | Yes                           |
| 20 | You decide not to feed the hamster, and it dies                         | You forget to feed the hamster, and it dies                                               | Yes                           |
| 21 | You purposefully dye it blue                                            | You mess up and his hair becomes blue                                                     | Yes                           |
| 22 | You feel bored with the conversation and hang up without saying goodbye | The telephone slips out of your hand and the connection is lost                           | Yes                           |

**Supplemental Table S6.2 Comparison of outcome SNPT-R stories (sensitivity analysis).** *(continued)*

|    | <b>Intentional</b>                                            | <b>Unintentional</b>                                                          | <b>Outcome same severity?</b> |
|----|---------------------------------------------------------------|-------------------------------------------------------------------------------|-------------------------------|
| 23 | You decide to sleep and lean on your neighbour's shoulder     | You fall asleep, slumped against your neighbour's shoulder                    | Questionable                  |
| 24 | You see your teacher coming and you slam the door in his face | You don't see your teacher coming and you shut the door right in front of him | Questionable                  |
| 25 | You sneeze in your classmate's face for a laugh               | All of a sudden you have to sneeze and you sneeze in a classmate's face       | Yes                           |
| 26 | You see the dog defecating on the street but you keep walking | You don't see the dog defecating on the street and you keep walking           | Yes                           |



Supplemental Figure S6.2 QR code for easy access to Supplemental Tables S6.3-4.

### **Supplemental Table S6.3 and Supplemental Table S6.4**

These supplemental tables are, due to their size, publicly available online at the Open Science Framework Database (Bas-Hoogendam, van Steenbergen, Kreuk, et al., 2017b). <https://osf.io/pt4qt/files/> - Results – Behavioral Data – S2 Dataset and S3 Dataset

