

Supplementary Material

1. Additional Personality Tests in ASD Patients and Healthy Control Subjects

	HC	ASD	t	df	p
	Mean	Mean			
	(± SD)	(± SD)			
NEO-FFI (N)	15.63	30.42	-7.59	51	<.001**
(n = 27/26)	(± 6.51)	(± 7.66)			
NEO-FFI (E)	30.70	15.96	8.42	51	<.001**
(n = 27/26)	(± 5.72)	(± 6.98)			
NEO-FFI (O)	30.96	27.42	2.21	51	.032*
(n = 27/26)	(± 6.00)	(± 5.67)			
NEO-FFI (V)	34.00	26.38	4.93	51	<.001**
(n = 27/26)	(± 4.68)	(± 6.45)			
NEO-FFI (C)	31.00	28.54	1.16	51	.252
(n = 27/26)	(± 8.15)	(± 7.27)			

Independent two-sample *t*-tests; $p < .05$; $p < .01$ Bonferroni-corrected

(Table 1) Results of the NEO-Five Factor Inventory NEO-FFI in Patients with Autism Spectrum Disorders (ASD) and healthy Control (HC) Subjects (Borkenau & Ostendorf 1993): Neuroticism (N), Extraversion (E), Openness (O), Agreeableness (V), Conscientiousness (C); SD = standard deviation

HAMD	IIP-C	IIP-C	IIP-C	IIP-C	IIP-C	IIP-C	IIP-C	IIP-C	PERT
n=17	(PA)	(BC)	(DE)	(FG)	(HI)	(JK)	(LM)	(NO)	40
	n=26	n=26	n=26	n=26	n=26	n=26	n=26	n=26	n=25

2.94	8.81	12.88	14.15	18.65	19.31	16.19	14.62	9.58	27.04
± 3.85	± 4.66	± 6.04	± 4.70	± 5.49	± 5.76	± 7.30	± 5.56	± 5.64	± 6.39

(Table 2) Additional Neuropsychological Data Solely for Patients with Autism Spectrum Disorders: Results of the Short Version of the Inventory for Interpersonal Problems (IIP-C; Horowitz et al. 2000) and of the Hamilton Depression Scale (Hamilton 1960) (PA = dominant, BC = aggressive, DE = repellent, FG = introverted, HI = self-confident, JK = indulgent, LM = caring, NO = intrusive)

2. Applied criteria for the Autism Diagnostic Observation Schedule – Generic (ADOS-G, Module 4; Lord et al. 1999)

Patients were either diagnosed at our department or had already been diagnosed with ASD by an experienced psychiatrist, elsewhere. 14 of our high functioning ASD patients (8 males, 6 females) fulfilled the ADOS-G Module 4 criteria for autism spectrum disorders (ADOS score ≥ 7 defined the ASD+ group), and 14 did not (ASD- group, 7 males, 7 females). In the ASD- group, diagnosis of ASD was thoroughly confirmed by an additional interview of close relatives. Interviews were geared to the Autism Diagnostic Interview – Revised (ADI-R; Lord et al. 1994), but not standardized, as especially the ADI-R is supposed to have only low sensitivity when administered to diagnose adult patients due to memory effects in parents because of the long latency between patients' age and the items of interest (mostly concerning the age of 4-5 years) (Seltzer et al. 2003). However, both sub-groups of patients met the cut-off for ASD according to the Autism Spectrum Quotient (AQ; Baron-Cohen et al. 2001).

There was no significant difference between the two ASD “sub-groups” above (ASD < 7) and below (ASD ≥ 7) the ADOS cut-off score in terms of to gender (*Pearson* $\chi^2(1) = .14, p = .71$), age, education, neuropsychological, and psychopathological results (see Table 3a). Particularly, both groups equivalently exhibited ASD-typical alexithymic traits and impairments on the level of emotion recognition.

Likewise, both groups did not differ with regard to reaction times (Table 3b).

	ASD < 7	ASD ≥ 7	t	df	p
	Mean	Mean			
	(± SD)	(± SD)			
Age (years)	31.43	31.36	.02	26	.98
(n = 14/14)	(±8.56)	(±9.68)			
Education	12.86	12.50	1.16	26	.26
(years)	(±.36)	(±1.09)			
(n = 14/14)					
IQ	109.92	108.29	.46	25	.65
(n = 13/14)	(±8.31)	(±10.06)			
Digit span	8.92	9.29	17	-.36	.722
forward	(±1.83)	(±2.63)			
(n = 12/7)					
Digit span	8.17	8.57	17	-.35	.734
backward	(±1.99)	(±3.15)			
(n = 12/7)					
Lexical	16.75	15.86	17	.28	.78
fluency	(±4.92)	(±9.17)			
(n = 12/7)					
Lexical	17.25	16.14	17	.55	.59
flexibility	(±3.89)	(±4.88)			
(n = 12/7)					
Semantic	20.17	15.29	17	2.07	.05
fluency	(±5.62)	(±3.40)			
(n = 12/7)					
Semantic	18.18	16.86	16	.60	.56
flexibility	(±3.40)	(±5.98)			
(n = 12/7)					
Difference	21.70	11.79	17	1.61	.13

score TMT-B	(±15.04)	(±7.74)			
- TMT-A					
(seconds)					
(n = 12/7)					
AQ	39.75	35.93	1.25	24	.22
(n = 12/14)	(±7.83)	(±7.70)			
TAS20	61.83	58.43	.76	24	.46
(n = 12/14)	(±14.15)	(±8.50)			
NSAd	4.43	4.29	.18	26	.46
(n = 27/26)	(±1.99)	(±2.13)			
HAMD	2.83	3.20	-.17	15	.87
(n = 12/5)	(±4.24)	(±3.11)			
ADOS-G	3.64	11.07	-9.46	26	< .001**
(n = 14/14)	(±1.22)	(±2.67)			
PERT40	26.38	27.75	-.53	23	.60
(n = 13/12)	(±7.29)	(±5.50)			

Independent two-sample *t*-tests; $p < .05$; $p < .003$ *Bonferroni*-corrected

(Table 3a) Demographical, Neuropsychological, and Psychopathological Data of Autistic Patients Above (ASD ≥ 7) and Below (ASD < 7) ADOS Cut-Off for an Autism Spectrum Disorder; ASD = patients with autism spectrum disorders; SD = standard deviation; AQ = Autism Quotient; NSAd = Scale for socially desirable behavior; TAS20 = Toronto Alexithymia Scale (Hamilton 1960); TMT-A/B = Trail Making Test; HAMD = Hamilton Depression Scale; PERT40 = Penn Emotion Recognition Test (Kohler et al. 2004)

	ASD < 7	ASD ≥ 7	<i>t</i>	df	<i>p</i>
	Mean	Mean			
	(± SD)	(± SD)			
SE	2.97	3.23	-.75	26	.46
(n = 14/14)	(±.90)	(±.89)			
IND	2.88	3.14	-.83	26	.42
(n = 14/14)	(±.74)	(±.92)			
BL	2.80	3.05	-.78	26	.44
(n = 13/14)	(±.84)	(±.86)			

Independent two-sample *t*-tests; $p < .05$; $p < .02$ Bonferroni-corrected

(Table 3b) Reaction Times of Autistic Patients Above (ASD ≥ 7) and Below (ASD < 7) ADOS Cut-Off for an Autism Spectrum Disorder; ASD = patients with autism spectrum disorders; SD = standard deviation; SE = social-ethical dilemmas; IND = individual gain vs. collective losses dilemmas; BL = high-level baseline (non-moral daily dilemmas)

3. Stimulus Selection

A set of 97 moral dilemmas was rated in a behavioral pre-study on 15 healthy males and 16 healthy women between 18 and 65 years of age. Five-point bipolar rating scales were used assessing realism, emotional involvement, the strength of the induced dilemma, and how easy it was to put oneself in the respective position of the agent (from -2 representing absolute disagreement to +2 equalizing absolute accordance).

20 dilemmas of each category were chosen so that the rating results for the three dilemma groups – social-ethical, individual gain vs. collective losses, and non-moral daily dilemmas – did not differ regarding realism, the strength of the induced dilemma, and how good participants were able to put themselves into the drawn situations (Figure 1; for statistical data see main document).

Please insert Figure 1 about here.

4. Moral Decision Making (vs. Baseline) – Brain Activation Separated for the Dilemma Processing and Solution Selection

Group(s)	Region	BA	Side	k	t	MNI-Coordinates		
						x	y	z
Moral ans vs. BL ans								
HC > ASD	N.S.							
ASD > HC	N.S.							
Moral txt vs. BL txt								
HC > ASD	N.S.							
ASD > HC	Precuneus	BA7	R	123	4.36	12	-67	31
	Posterior cingulate cortex		L	52	4.00	-15	-61	10
	Anterior cingulate cortex		R	21	4.35	9	35	-8

(Table 4) Brain Activation for the Moral vs. BL Contrasts Separated for the Dilemma Processing and Solution Selection for Patient with Autism Spectrum Disorders (ASD) and Healthy Controls (HC): flexible factorial analysis, $p < .05$ Monte-Carlo corrected, extent threshold = 5 voxels; Moral = combined social-ethical (SE) and individual gain vs. collective losses (IND) dilemmas; BL = (weighted) non-moral dilemma high-level baseline; ans = answer sentence; txt = dilemma text; BA = Brodmann's Area; N.S. = Not significant; L = Left; R = Right

Please insert Figure 2a and 2b about here.

5. Brain Activation for all Morality Contrasts after Exclusion of Medicated Patients (n=5) from the Analysis

In order to assure that our main results discussed were not affected by medication effects, we recalculated the main group comparisons after excluding all patients medicated at time of the study.

Group(s)	Region	BA	Side	k	t	MNI-Coordinates		
						x	y	z
Moral vs. BL								
HC > ASD	Inferior frontal gyrus		L	22	3.94	-39	38	10
ASD > HC	Anterior cingulate cortex		R	19	4.14	6	41	-8
	Posterior cingulate gyrus		R	20	3.91	9	-61	22
	Supramarginal gyrus		R	31	4.87	45	-46	34
SE vs. BL								
HC > ASD	N.S.
ASD > HC	Posterior cingulate cortex		L	30	4.02	-18	-55	22
	Supramarginal gyrus		R	38	4.45	42	-40	28
IND vs. BL								
HC > ASD	Amygdala		L	18	4.33	-15	-13	-20
	Inferior frontal gyrus		L	29	4.20	-39	35	10
	Precentral gyrus		R	18	4.16	54	8	7
ASD > HC	Anterior cingulate cortex		R	18	4.05	6	41	-8
	Posterior cingulate cortex	BA23	R	19	4.17	6	-61	19

	Superior frontal gyrus		22	4.25	12	62	19
SE vs. IND							
HC > ASD	Middle frontal gyrus	R	32	4.08	45	11	34
IND vs. SE							
HC > ASD	Anterior cingulate cortex	L	28	4.12	-3	29	10

(Table 5) Group Comparisons for all Morality Contrasts after Excluding Medicated Patients: flexible factorial analysis, $p < .05$ *Monte-Carlo* corrected, extent threshold = 5 voxels (Moral = combined social-ethical (SE) and individual gain vs. collective losses (IND) dilemmas; BL = (weighted) non-moral high-level baseline); BA = *Brodmann's Area*; ASD = Patient with autism spectrum disorder; HC = Healthy controls; L = Left; R = Right)

References

Borkenau, P., Ostendorf, F. (1993) NEO-Fünf-Faktoren-Inventar (NEO-FFI) nach Costa und McCrae. Göttingen: Hogrefe.

Hamilton, M. (1960) A rating scale for depression. *J Neurol Neurosurg Psychiatry*, 23, 56-62.

Horowitz, L.M., Strauß, B. & Kordy, H. (2000) Inventar zur Erfassung interpersonaler Probleme – Deutsche Version (IIP-D). Weinheim: Beltz Test GmbH.

Kohler, C.G., Turner, T.H., Gur, R.E. & Gur, R.C. (2004) Differences in facial expressions of four universal emotions. *Psychiatry Res*, 128, 235-244.

Lord, C., Rutter, M. & Le Couteur, A. (1994) Autism Diagnostic Interview-Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *J Autism Dev Disord*, 24, 659-685.

Lord, C., Rutter, M., DiLavore, P.C. & Risi, S. (1999) Autism Diagnostic Observation Schedule. Los Angeles, CA: Western Psychological Services.

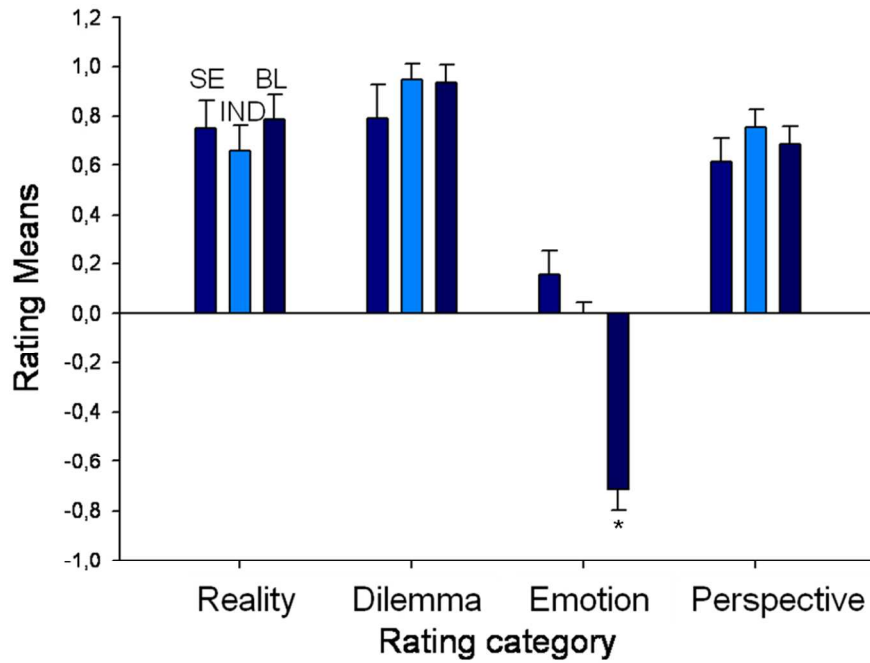
Schmidt, K.-H. & Metzler, P. (1992) Wortschatztest (WST). Weinheim: Beltz Test GmbH.

Seltzer, M.M., Krauss, M.W., Shattuck, P.T., Orsmond, G. Swe, A. & Lord, C. (2003) The symptoms of autism spectrum disorders in adolescence and adulthood. *J autism Dev Disord*, 33, 565-581.

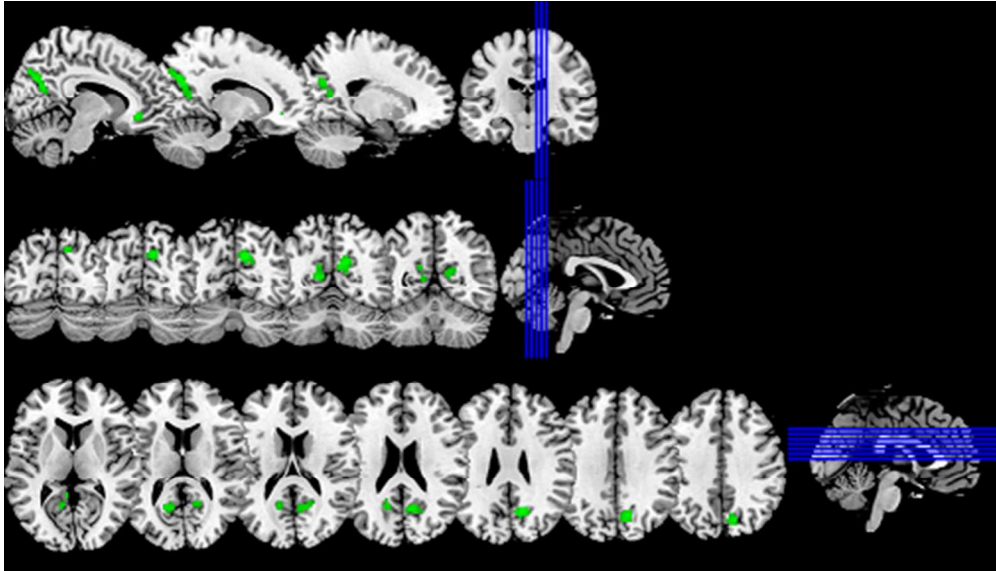
Figure Descriptions

(Figure 1) Final Rating Results for the Dilemma Stimuli for social-ethical dilemmas (SE), individual gain vs. collective losses dilemmas (IND), and the non-moral dilemma high-level baseline (BL)

(Figure 2) Brain Activation for Moral vs. BL during the Processing of the Dilemmas; flexible factorial ANOVA; $p < .05$ Monte-Carlo corrected; stronger activation (*green*) in patients with autism spectrum disorder (ASD) as compared to healthy controls (HC) in the precuneus, posterior cingulate cortex, and anterior cingulate gyrus (ACC) and no significant results for HC > ASD; Moral = combined social-ethical (SE) and individual gain vs. collective losses (IND) dilemmas; BL = (weighted) non-moral dilemma high-level baseline; ans = answer sentence; txt = text of the moral dilemmas



(Figure 1) Rating Results for the Dilemma Stimuli for social-ethical dilemmas (SE), individual gain vs. collective losses dilemmas (IND), and the non-moral dilemma high-level baseline (BL)
 283x205mm (96 x 96 DPI)



(Figure 2) Brain Activation for Moral vs. BL during the Processing of the Dilemmas; flexible factorial ANOVA; $p < .05$ Monte-Carlo corrected; stronger activation (green) in patients with autism spectrum disorder (ASD) as compared to healthy controls (HC) in the precuneus, posterior cingulate cortex, and anterior cingulate gyrus (ACC) and no significant results for HC > ASD; Moral = combined social-ethical and individual gain vs. collective losses dilemmas; BL = (weighted) non-moral dilemma high-level baseline
134x76mm (96 x 96 DPI)