

## Introducing the English EmpaToM task: A tool to assess empathy, compassion, and theory of mind in fMRI studies

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### ABSTRACT

**Introduction:** Though empathy, compassion, and Theory of Mind (ToM) are related, they have been distinguished conceptually and empirically across behavioural and neuroimaging experiments. The EmpaToM task was the first realistic paradigm developed for use in functional Magnetic Resonance Imaging (fMRI), which can reliably detect and distinguish three different types of neural pathways crucial for understanding others with a single well-controlled task. Though the paradigm holds the potential for use in research settings as well as clinical practice, it has thus far only been validated in German speaking populations, using stimuli in German language, restricting its usability across countries. We present an English-language translation of the original paradigm here.

**Method:** Thirty-two English speaking adults underwent fMRI scanning, during which we collected neural and behavioural data as in the original validation of the EmpaToM task.

**Results:** Apart from minor differences, these results replicated the main behavioural and neural findings observed during the validation of the German paradigm. Participants reported increased negative affect and activity in brain regions previously associated with empathy when observing video clips with negative vs neutral valence. They further reported increased compassion. The pattern of neural activity differentiating empathy from compassion was largely consistent with previous research. Increased activity in regions previously associated with ToM were observed in response to stimuli with ToM vs factual reasoning content.

**Conclusion:** We therefore conclude that the English version of the EmpaToM task can be used to reliably assess empathy, compassion, and ToM on a behavioural as well as neuronal level across English speaking countries and institutions.

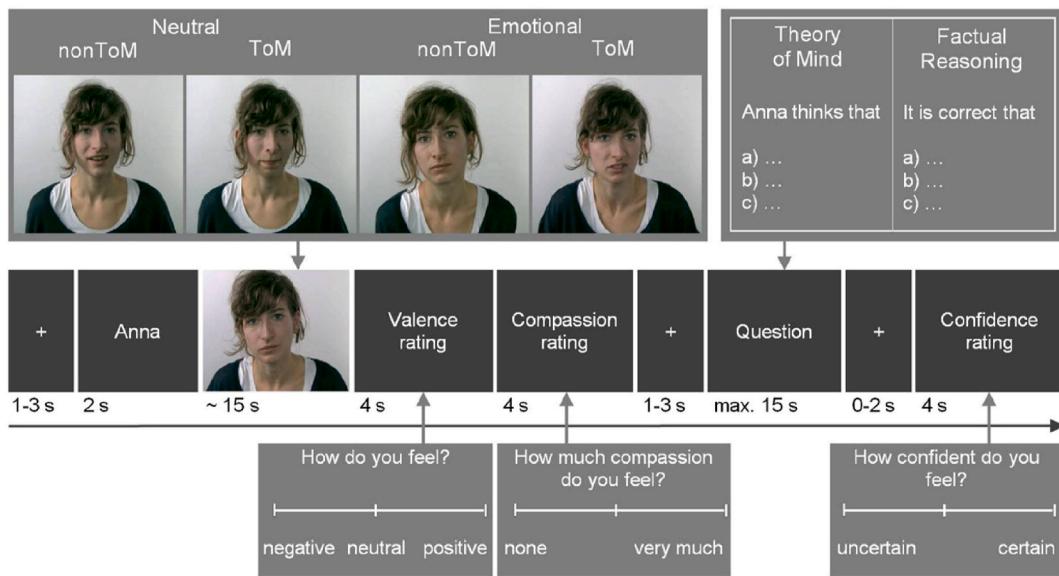
### 1. Introduction

Empathy, compassion, and Theory of Mind (ToM) are crucial processes during social interaction (Henry et al., 2016; Kanske, 2018; Preckel et al., 2018; Schurz et al., 2021; Singer, 2006; Stietz et al., 2019). Empathy is a socio-affective process, which can be defined as sharing the emotions and feeling states of another individual, whilst explicitly knowing that the feeling originates from the other person (de Vignemont and Singer, 2006). Compassion is a complimentary social emotion

characterised by feelings of warmth and concern in response to another's suffering, going along with the motivation to help (Goetz et al., 2010; Singer and Lamm, 2009). ToM refers to a socio-cognitive process, during which one takes the perspective of another individual, and infers their thoughts and beliefs (Frith and Frith, 2003; Saxe and Kanwisher, 2003). This process entails the representation of another's mental state (including beliefs, thoughts, and emotions) with the help of abstract, propositional knowledge. Though related to each other, empathy, compassion, and ToM refer to distinct processes which rely on distinct

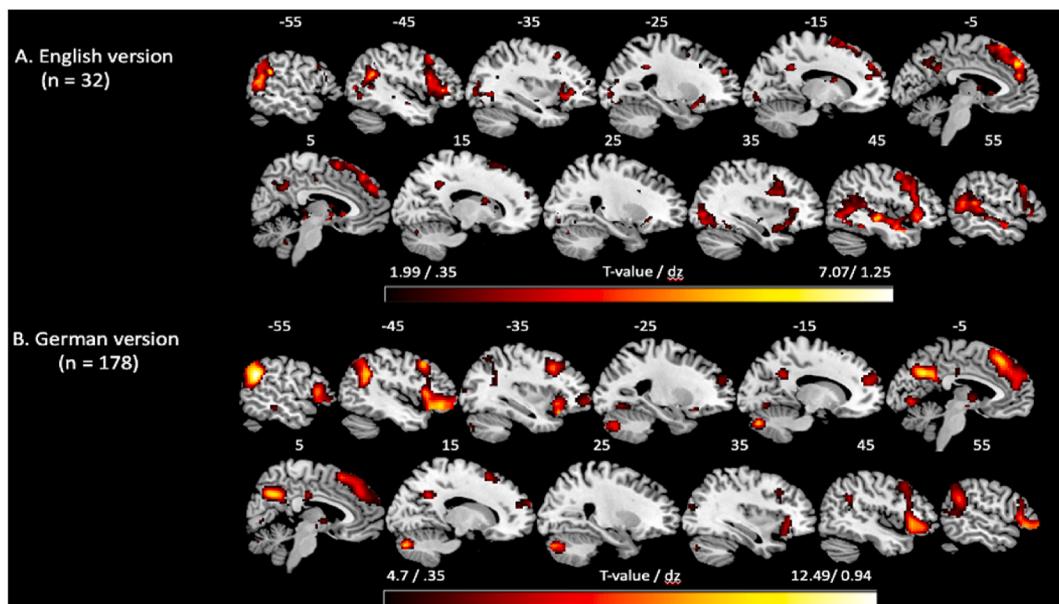
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**Fig. 1.** EmpaToM Task Design Overview: Emotionality of Video and ToM Video Content Design with the Four Distinct Types of Video Content

Note. Image from Kanske et al. (2015). Image shows an overview of an EmpaToM trial sequence. The video was followed by a valence rating scale, a compassion rating scale, a multiple-choice question (ToM vs factual reasoning), and a confidence rating regarding their performance in the previous question.



**Fig. 2.** Neural Activation Across the Emotionally Negative > Emotionally Neutral Video Contrast in Response to A) the English EmpaToM Task, as Assessed in the Present Experiment, and to B) the German EmpaToM Task, as Assessed During the Original Validation of the Paradigm

Note. Results are displayed on sagittal slices of the *ch2better* template using MRICron. Numbers above each slice represent MNI coordinates. The colour continuum bar below the slices indicates the intensity/effect of the neural activation from lowest intensity/effect to highest intensity/effect. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

neural networks (Kanske et al., 2015, 2016; Preckel et al., 2018; Singer, 2006, 2012; Stietz et al., 2019).

Earlier work in the field of empathy on the one hand (Lamm et al., 2011; Singer et al., 2004) and ToM on the other hand (Bzdok et al., 2012; Frith and Frith, 2003, 2006; Mitchell, 2005; Saxe and Kanwisher, 2003; Schurz et al., 2021) had distinguished empathy and ToM on the behavioural and neural level (Singer, 2006, 2012). Behavioural studies demonstrate that performance on tasks developed to assess either socio-affective processes, such as the Reading the Mind in the Eyes task (Baron-Cohen et al., 2001), or socio-cognitive processes, such as the Strange Stories task (Happé, 1994; White et al., 2009), is not correlated

among children or adults (Dziobek et al., 2006; Rice et al., 2016). Other studies identified double dissociations across similar tasks in patients with lesions in relevant brain regions (Shamay-Tsoory et al., 2009; Shamay-Tsoory and Aharon-Peretz, 2007). On the neural level, brain regions implicated in socio-cognitive processes showed considerable overlap with the default mode network, a neural network related to self-generated cognition decoupled from the physical world (Andrews-Hanna et al., 2014; Schurz et al., 2021; Yeo et al., 2011). In a similar manner, one does not have direct perceptual access to the contents of someone else's mind whilst engaging in ToM (Frith and Frith, 2003; Lieberman, 2007). Brain regions implicated in socio-affective processes

**Table 1**

Neural activity observed during emotionally negative > emotionally neutral videos.

Region	H	Cs	Peak MNI Coordinate			Peak p-value	Peak t-value
			X	Y	Z		
Superior Medial Frontal Gyrus	B	3594	-4	46	38	<.001	7.07
Superior Medial Frontal Gyrus (including Anterior Cingulate Cortex)	-	-	-6	48	24	<.001	4.83
Superior Medial Frontal Gyrus (including Supplementary Motor Area)	-	-	-6	26	60	<.001	4.77
Inferior Parietal Lobule – Supramarginal Gyrus	L	2335	-56	-44	28	<.001	6.39
Inferior Parietal Lobule – Angular Gyrus	-	-	-44	-52	24	<.001	5.50
Posterior Superior Temporal Gyrus	-	-	-52	-56	8	<.001	5.12
Posterior Superior Temporal Gyrus	R	7070	64	-34	14	<.001	6.18
Middle Superior Temporal Gyrus	-	-	44	-24	-6	<.001	5.77
Inferior Occipital Gyrus	-	-	40	-70	-6	<.001	5.34
Inferior Frontal Gyrus	L	2434	-44	32	4	<.001	5.83
Anterior Insula	-	-	-32	24	-4	<.001	4.82
Inferior Frontal Gyrus – Pars Triangularis	-	-	-36	34	0	<.001	4.54
Caudate	B	687	8	16	0	<.001	4.31
Caudate	-	-	10	2	10	<.001	4.13
Hypothalamus	-	-	4	-2	-8	<.001	4.00
Posterior Cingulate Gyrus	B	961	-24	-44	36	<.001	4.02
Precuneus	-	-	-10	-50	32	<.001	3.74
Precuneus	-	-	12	-48	38	<.001	3.66
Cerebellum	R	53	22	-72	-26	.001	3.52
Caudate	L	30	-8	14	0	.001	3.38
Precentral Gyrus – Rolandic Operculum	R	29	58	2	16	.003	2.89
Cerebellum	R	19	6	-52	-38	.006	2.68
Mid Cingulate Gyrus	B	65	6	-16	44	.007	2.62
Mid Cingulate Gyrus	-	-	-2	-16	40	.009	2.49
Supplementary Motor Area	-	-	8	-20	52	.011	2.40
Cerebellum	L	10	-4	-54	-36	.008	2.54
Middle Temporal Lobe	L	14	-42	-26	-6	.010	2.47
Thalamus	R	15	24	-30	6	.010	2.47
Mid Frontal Gyrus	L	17	-28	20	34	.010	2.45
White Matter	L	16	-18	-6	16	.012	2.36

Note. H = hemisphere (L = left, R = right, B = bihemispheric). Cs = cluster size.

have been observed across the frontal cortex, including areas such as the inferior frontal gyrus (IFG) or the insula (Schurz et al., 2021), regions which have been found to play a role in both observing and experiencing certain emotions (Lamm et al., 2011; Rütgen et al., 2015).

Previous work further showed that though both empathy and compassion are social emotions, they do not only lead to distinct behavioural responses, but also rely on differentiable neural circuitries (Engen and Singer, 2015; Klimecki et al., 2013, 2014; Singer and Klimecki, 2014; Singer and Lamm, 2009). While compassion is an other-related emotion leading to positive feelings such as love, empathy is a self-related emotion which is often related to negative feelings including stress. As such, compassion has often been related to prosocial behaviour, whilst empathy can lead to withdrawal and nonsocial behaviour (Singer and Klimecki, 2014). In line with these findings, research revealed that after empathy training, activity increased in the insula and anterior cingulate cortex (ACC) when participants observed others in pain. These regions have previously been associated with pain

**Table 2**

Neural activity observed during the ROI analyses related to the emotionally negative > emotionally neutral videos.

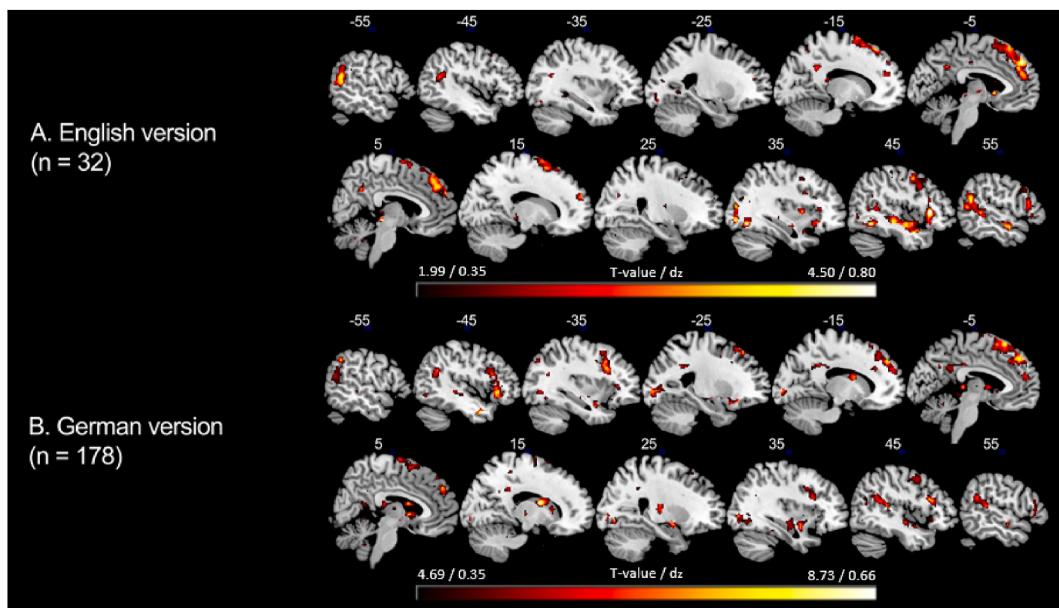
Region	H	Replicated	Peak p-value	Peak t-value	CsG	CsE
Superior Medial Frontal Cortex	B	Yes	<.001	7.07	1257	2764
Inferior Frontal Gyrus/ Middle Frontal/ Anterior Insula	L	Yes	.001	5.83	1027	1668
Inferior Frontal Gyrus/ Middle Frontal/ Anterior Insula	R	Yes	.010	4.87	737	1394
Precuneus	B	Marginal	.099	3.74	614	1004
TPJ-Angular/ Supramarginal Gyrus	L	Yes	<.001	6.39	599	1032
TPJ-Angular/ Supramarginal Gyrus/Middle Temporal Cortex	R	Yes	.009	4.73	448	702
Cerebellum	R	Yes	.023	3.46	219	23
Cerebellum	L	No	No voxels	–	186	–
Lingual Gyrus	L	No	.475	2.23	162	20
Ventral Striatum/ Caudate	B	Yes	.016	4.13	153	184
Middle Cingulate	B	No	.188	2.49	82	35
Middle Occipital	R	No	No voxels	–	30	–
Middle Temporal Cortex	L	No	No voxels	–	26	–
Middle Occipital	L	Yes	.008	3.02	13	3

Note. H = hemisphere (L = left, R = right, B = bihemispheric). CsG = cluster size in number of voxels in the German validation of the paradigm. CsE = cluster size in number of voxels in the English version of the paradigm, assessed during the present experiment.

perception and the personal experience of pain (e.g., Corradi-Dell'Acqua et al., 2016; Duerden and Albanese, 2013; Lamm et al., 2011; Singer et al., 2004). Compassion training, on the other hand, increased activity in regions related to positive affect and reward, such as the orbitofrontal cortex and striatum (Klimecki et al., 2013, 2014). This is in line with research indicating that heightened social connectedness is related to increased activity in similar brain regions, and an elevation in the experience of positive affect (Eisenberger and Cole, 2012).

Yet only more recently did the development of a novel experimental paradigm, the EmpaToM task (Kanske et al., 2015), make it possible to distinguish these different social processes within and between individuals in the same functional Magnetic Resonance Imaging (fMRI) task using ecologically valid video stimuli (Kanske et al., 2015; Tholen et al., 2020). It is the first such paradigm focusing on empathy, compassion, and ToM suitable for use in fMRI which can simultaneously investigate the behavioural and neural responses related to these social skills. The EmpaToM task involves naturalistic stimuli contributing to improving ecological validity, yet it remains a controlled task which may be administered in as little as 30 minutes. It can be used to investigate a range of timely and important questions regarding social cognition, such as how empathy, compassion, and ToM are processed and interconnected. The task could play a critical role in identifying particular impairments associated with social comprehension in psychopathology, as well as in determining the distinct developmental pathways linked to socio-affective versus socio-cognitive processes. Indeed, research suggests that such behavioural findings obtained using the EmpaToM task are replicable (Stietz et al., 2021). Furthermore, the task can aid in comprehending the impact of innovative interventions.

Despite the significance of this paradigm for the fields of social and cognitive neuroscience, it is currently only validated in German language as it was developed in the context of a large-scale longitudinal mental training study focusing on the trainability of different aspects of the social brain, the ReSource project (Singer et al., 2016), performed



**Fig. 3.** Neural Activation for the Parametric Empathy Rating During Videos in the A) English EmpaToM Task, as Assessed in the Present Experiment, and B) in the German EmpaToM Task, as Assessed During the Original Validation of the Paradigm

Note. Results are displayed on sagittal slices of the ch2better template from MRIcron. Numbers above each slice represent MNI coordinates. The colour continuum bar below the slices indicates the intensity/effect of the brain activation from lowest intensity/effect to highest intensity/effect. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

under the leadership of Prof. Dr. Tania Singer in the former Department of Social Neuroscience of the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany. The availability of this paradigm only in German language restricts its usability cross-nationally. Therefore, the present study introduces an English version of the EmpaToM task and compares its performance to the behavioural and neural results of the original German version. Our aim is to share this English version in an open-source manner, making stimuli available via the Open Science Framework (<https://osf.io/gfa3t>), allowing wider use of the paradigm for both research and clinical purposes.

### 1.1. The EmpaToM task

Throughout the task, empathy and ToM are manipulated using naturalistic video stimuli whereby actors tell allegedly autobiographic narratives. These ensure ecological validity, as realistic scenarios similar to encounters in real-world settings are used. The video stimuli entail either emotionally negative narratives involving human suffering, prompting an empathic and compassionate response, or neutral control narratives (Kanske et al., 2015). Subjective empathic responses are subsequently assessed through participants' ratings of their affective state. Specifically, participants are asked to respond to the question '*How do you feel?*' using a slider labelled '*negative*' on its left, and '*positive*' on its right side. Participants' ratings of high negative affect after an emotionally negative video would indicate empathy sharing of the narrator's emotion. Participants were next asked to indicate the amount of compassion experienced towards the individual in the video, using a slider labelled '*none*' on its left and '*very much*' on its right side to respond to the question '*How much compassion do you feel?*'. Higher ratings of compassion indicate increased emotions of care, concern, and kindness for the narrator.

The videos are also designed to either entail demands in ToM or not. ToM on the behavioural level is assessed by including multiple-choice questions following the ToM videos, requiring participants to make inferences about the actors' thoughts, goals, or intentions. Factual reasoning questions about the content of the videos are presented as a control. These instruct participants to select the one true statement

based on the contents of the video out of a total three statements presented on the screen, and further contribute a strength to the paradigm as many ToM tasks do not include direct control comparisons.

Neural activity corresponding to empathy is assessed by comparing neural responses when participants observe the emotionally negative videos to the neural responses elicited by emotionally neutral videos (Kanske et al., 2015). Parametric modulation of these results using the valence and compassion ratings identify any activity which is specific to compassion and empathy, as well as any shared neural activity. Neural activity related to ToM is assessed by comparing neural responses elicited by ToM questions to those observed when participants respond to non-ToM, factual reasoning questions.

### 1.2. Differentiating empathy, compassion, and ToM using the EmpaToM task

Across three studies, Kanske and colleagues validated the behavioural and neural components of the EmpaToM task against pre-existing validated measures of empathy and ToM (2015). The neural results were additionally validated against a previous meta-analysis of the neural circuits associated with either process (Bzdok et al., 2012). Compassion was differentiated from empathy through identifying any shared and distinguished neural responses to the emotionally negative vs neutral videos using parametric modulation of valence and compassion ratings. These analyses confirmed that empathy, compassion, and ToM can be reliably separated from each other.

Specifically, valence and compassion ratings in the EmpaToM task correlated significantly with those in the Socio-Affective Video Task (Klimecki et al., 2013), an established paradigm that can distinguish empathy and compassion both on a behavioural as well as neuronal level (Kanske et al., 2015). ToM performance in the EmpaToM task was associated with the most advanced level of ToM in the Kinderman Imposing Memory Task (Kinderman et al., 1998) and with performance on the Samson Visual Perspective Taking Task (Samson et al., 2010), tasks designed to assess ToM performance. The Saxe False Belief Task (Dodell-Feder et al., 2011) was additionally used to validate the paradigm inside the fMRI scanner.

**Table 3**  
Parametric empathy rating during videos.

Region	H	Cs	Peak MNI Coordinate			Peak p-value	Peak t-value
			X	Y	Z		
Anterior insula	R	626	44	24	2	<.001	4.50
Inferior frontal gyrus	R	-	52	22	18	.002	3.10
Anterior insula	R	-	34	26	-10	.003	2.95
Superior frontal gyrus	R	3268	0	46	38	<.001	4.28
Superior frontal gyrus	R	-	0	38	46	<.001	3.94
Superior medial frontal gyrus	R	-	10	58	26	<.001	3.69
Inferior occipital gyrus	R	688	46	-54	-12	<.001	4.05
Inferior occipital gyrus	R	-	34	-82	-6	<.001	3.96
Inferior occipital gyrus	R	-	34	-68	-12	<.001	3.88
Midbrain	R	154	8	-26	-6	<.001	3.96
Midbrain	L	-	-2	-28	-4	.001	3.28
Thalamus	R	-	4	-30	4	.013	2.33
Ventral striatum	L	20	-8	12	-2	<.001	3.80
Superior temporal gyrus	R	1636	48	-8	-12	<.001	3.77
Superior temporal gyrus	R	-	62	-44	20	<.001	3.69
Pole of superior temporal gyrus	R	-	44	6	-22	<.001	3.67
Superior temporal gyrus	L	484	-52	-56	20	<.001	3.70
Superior temporal gyrus	L	-	-46	-50	24	.006	2.69
Superior temporal gyrus	L	-	-56	-52	34	.006	2.64
Mid occipital gyrus	L	46	-30	-78	16	.001	3.33
Mid occipital gyrus	L	-	-26	-82	26	.020	2.14
Precuneus	R	209	4	-54	34	.001	3.22
Mid cingulate	L	-	-12	-48	34	.002	3.04
Precuneus	R	-	10	-52	44	.016	2.26
III and IV ventricles	B	22	0	0	-10	.002	3.06
Anterior insula	R	36	34	6	4	.002	3.03
Cerebellum	R	18	20	-76	-24	.004	2.85
Cerebellum	R	17	2	-68	-22	.004	2.84
Lateral ventricle body	L	41	-16	-34	16	.005	2.77
Lateral ventricle atrium	L	-	-24	-38	12	.018	2.19
Thalamus	R	10	8	0	8	.005	2.76
Thalamus	L	48	-2	-12	0	.005	2.74
Thalamus	L	-	-2	-4	2	.005	2.73
Superior parietal	L	87	-18	-62	60	.006	2.70
Superior parietal	L	-	-22	-58	66	.008	2.57
Middle occipital	R	31	42	-66	10	.006	2.69
Middle temporal	R	-	36	-64	18	.016	2.25
Middle occipital	L	24	-36	-62	22	.006	2.68
Precentral	L	18	-48	12	48	.006	2.67
Frontal middle	L	-	-40	10	58	.013	2.32
TPJ – angular/supramarginal gyrus	L	32	-60	-42	26	.006	2.66
Putamen	R	16	28	-10	14	.008	2.53
Fusiform gyrus	L	70	-22	-88	-2	.008	2.53
Fusiform gyrus	L	-	-26	-86	-12	.011	2.42
Lateral ventricle frontal	L	31	-2	18	12	.009	2.48
Lateral ventricle frontal	L	-	-8	14	16	.022	2.09
Lateral occipital	L	15	-34	-76	-12	.009	2.48
Central sulcus	L	16	44	-26	56	.010	2.47
Middle occipital gyrus	R	15	24	-70	26	.010	2.47
Dorsal anterior cingulate gyrus	L	15	-6	-20	38	.010	2.45
Lingual gyrus	L	22	-28	-56	0	.011	2.42
Cerebellum	R	17	6	-52	-32	.012	2.39
Cerebellum	R	-	0	-60	-34	.014	2.29
Anterior insular	L	30	-36	24	-4	.012	2.37
Anterior insular	L	-	-42	18	-8	.020	2.14
Posterior middle temporal	L	21	-40	-44	0	.013	2.33
Parahippocampal gyrus	L	-	-32	-44	-6	.020	2.14

**Table 3 (continued)**

Region	H	Cs	Peak MNI Coordinate			Peak p-value	Peak t-value
			X	Y	Z		
Superior occipital gyrus	L	14	-20	-76	32	.014	2.29
Middle frontal gyrus (posterior segment)	R	11	32	24	22	.015	2.26
Postcentral gyrus	R	42	52	-12	50	.016	2.25
Postcentral gyrus	R	15	42	-24	48	.017	2.22
Middle occipital gyrus	R	17	36	-72	22	.018	2.19
Superior frontal gyrus (posterior segment)	R	11	20	-6	56	.019	2.16
Inferior frontal gyrus pars triangularis	L	10	-46	20	2	.020	2.13

Note. H = hemisphere (L = left, R = right, B = bihemispheric). Cs = cluster size.

**Table 4**

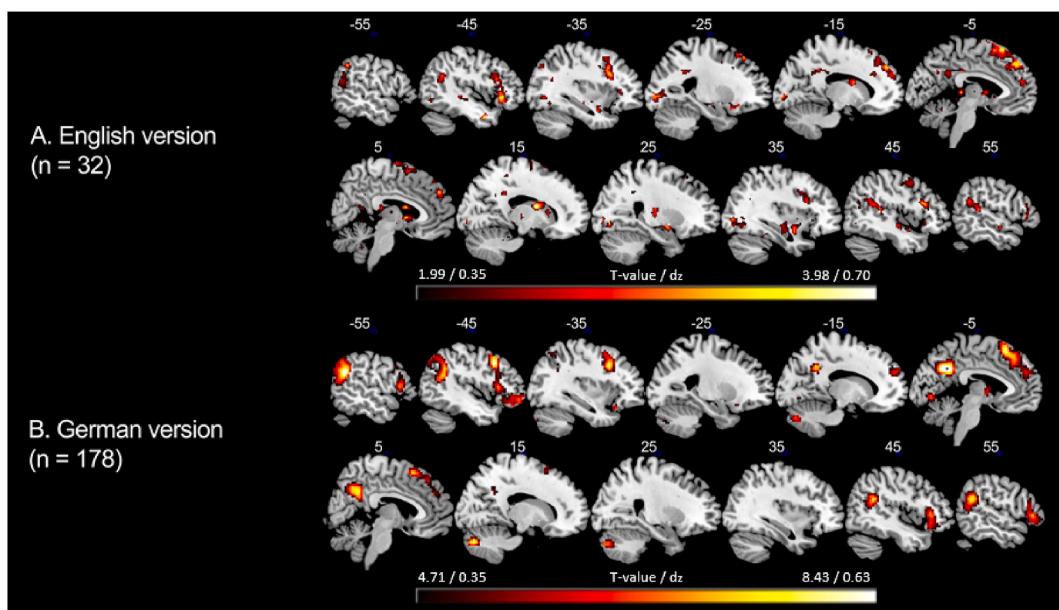
Neural activity observed during the ROI analyses related to parametric empathy rating during videos.

Region	H	Replicated	Peak MNI Coordinate		Peak p-value	Peak t-value	CsG	CsE
			X	Y				
TPJ – angular/supramarginal gyrus	L	No	.063	3.70	297	367		
Precuneus	L	No	0.167	3.22	338	236		
TPJ – supramarginal/angular gyrus	R	Yes	0.041	3.66	154	94		
Cerebellum	R	Yes	0.027	2.50	111	2		
Inferior orbitofrontal/IFG	L	No	0.063	2.37	338	113		
Middle frontal	L	No	0.356	2.06	74	11		
Inferior orbitofrontal/IFG	R	Yes	0.006	4.50	151	284		
Superior medial frontal	B	Yes	0.022	4.28	348	814		
Cerebellum	L	No	No voxels	–	59	–		
Middle cingulate	R	No	No voxels	–	19	–		

Note. H = hemisphere (L = left, R = right, B = bihemispheric). CsG = cluster size in number of voxels in the German validation of the paradigm. CsE = cluster size in number of voxels in the English version of the paradigm, assessed during the present experiment.

The fMRI analyses implicated activation in the bilateral anterior insula (AI), IFG, medial prefrontal cortex (MPFC) and dorsal ACC when comparing neural activity in response to emotionally negative > emotionally neutral videos (Kanske et al., 2015). Despite several brain regions showing overlapping activation indicative of empathy and compassion, a few differences were also present. In response to empathy, unique activity was observed in the AI, but not in response to compassion. In response to compassion, unique activity was observed in the ventral striatum, but not in response to empathy. These results were in accordance to previous findings showing a crucial role of the AI for empathy for pain (Lamm et al., 2011) and of the striatum and other reward-related areas for compassion (Klimecki et al., 2013, 2014; Singer and Klimecki, 2014).

In relation to ToM, the results implicated activation in the TPJ bilaterally, the superior temporal sulcus (STS), temporal poles (TP), MPFC, and the precuneus when comparing neural activity in response to the ToM > non-ToM stimuli (Kanske et al., 2015). These neural responses to empathetic and ToM stimuli yielded a similar pattern to those observed in response to the comparison tasks utilized specifically to assess these separate processes. Activity across these key brain regions remained significant when directly comparing the Empathy > ToM and ToM > Empathy contrasts to each other. The results also largely overlapped with those of a large-scale activation likelihood estimation meta-analysis investigating neuroimaging studies conducted on empathy and ToM (Bzdok et al., 2012). In summary, the EmpaToM task



**Fig. 4.** Neural Activation for the Parametric Compassion Rating During Videos in the A) English EmpaToM Task, as Assessed in the Present Experiment, and B) in the German EmpaToM Task, as Assessed During the Original Validation of the Paradigm

**Note.** Results are displayed on sagittal slices of the *ch2better* template using MRIcron. Numbers above each slice represent MNI coordinates. The colour continuum bar below the slices indicates the intensity (effect) of the neural activation from lowest intensity/activity to highest intensity/activity for empathy (black to white) and ToM (deep blue to light blue). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

allows the investigation of brain-behaviour associations for empathy, compassion, and ToM, as well as the distinct neural networks corresponding to these processes (Kanske et al., 2016).

### 1.3. Significance of the EmpaToM task

Measuring empathy, compassion, and ToM with the same paradigm and thus based on the same stimulus material made the dissociation of these different social skills and underlying neuronal routes possible and helps to shed light on differences in these processes across different populations. For example, recent research showed that ToM is impaired in aging adults compared to young adults, whereas there was no indication of decline in empathy (Reiter et al., 2017). The EmpaToM task may be applied in clinical research and clinical settings as well, as selective impairments have been observed in certain disorders uniquely affecting either empathy or ToM (Preckel et al., 2018). For example, individuals with autism show impairments in ToM abilities (Frith, 1994; Frith and Happé, 2005), but not empathy (when controlling for alexithymia; Bird et al., 2010; Singer, 2006). On the contrary, psychopathy is characterized by impaired empathy, but intact ToM (Winter et al., 2017). The EmpaToM task has been further used to study how individual differences in empathy and ToM influence behaviour. For example, empathy and ToM differentially predict charitable giving and prosocial decision-making (Tusche et al., 2016). Implementing the paradigm in combination with an ecological momentary assessment protocol, results additionally suggest that the EmpaToM task can predict real-world perspective-taking (Hildebrandt et al., 2021).

Whereas previous research shows that the experience of empathy may lead to empathic distress, compassion is a more adaptive response to others' suffering. The experience of increased empathic distress may affect certain groups more frequently, including health professionals. Compassion can be enhanced with training (Trautwein et al., 2020; Valk et al., 2017), simultaneously leading to a decrease in empathic distress (Dowling, 2018; Jazaieri et al., 2018; Klimecki et al., 2013, 2014; Singer and Engert, 2019). To understand and optimise compassion training, it is important to be able to accurately track its effects. Crucially, the original EmpaToM task was developed with five parallel test versions, i.

e., five sets of videos depicting independent scenarios while containing matched emotional and ToM content (Kanske et al., 2015). The parallel test versions allow its use in longitudinal research, making it possible, for example, to assess the unique effects of interventions and social and affective training programs on empathy, compassion, and ToM. Furthermore, this task can also be adapted for use in younger populations (Breil et al., 2021).

The potential applications of the EmpaToM task are widespread.<sup>1</sup> Further research even indicates that individual differences in the social capacities assessed by the task also relate to individual differences in brain structure (Valk et al., 2016). Beyond enabling its use across English-speaking research and clinical contexts, this conceptual replication of the original study will also add to the limited number of studies that have tried to replicate fMRI research. Given the current replication crisis in psychology (Anvari and Lakens, 2018; Lindsay, 2015; Open Science Collaboration, 2015) and the high cost associated with fMRI (and thus lack of replication studies in this field), there is a strong need to get more data on how replicable fMRI studies are.

### 1.4. Overview of the present research

The aim of this study is to replicate the results of the original EmpaToM task with a paradigm that matches the original task but with English speaking actors. We created two parallel tests, making the English version suitable for longitudinal measurement. We predicted that the results of this replication would match the behavioural and fMRI results of the original EmpaToM task. Specifically, we predicted that emotionally negative videos would elicit more negative affect (Hypothesis 1) and compassion (Hypothesis 2) than emotionally neutral videos on the behavioural level. In line with the findings observed with the original EmpaToM task, we predicted that participants' performance

<sup>1</sup> The EmpaToM task may also be used to assess the neural correlates of metacognitive ability and related self-perceived accuracy of one's own metacognitive abilities (Kanske et al., 2015; Molenberghs et al., 2016). Due to a limited sample size, the present experiment did not achieve optimal power for the replication of these analyses.

**Table 5**  
Parametric compassion rating during videos.

Region	H	Cs	Peak MNI Coordinate			Peak <i>p</i> -value	Peak <i>t</i> -value
			X	Y	Z		
Ventral striatum	R	481	12	2	18	<.001	4.59
Ventral striatum	R	–	8	4	2	<.001	3.75
Caudate	R	–	22	10	20	.001	3.29
Superior medial frontal gyrus	L	1955	–2	42	42	<.001	4.21
Superior frontal gyrus	L	–	–4	26	64	<.001	3.99
Superior frontal gyrus	R	–	4	50	36	.001	3.51
Posterior superior temporal	R	569	42	–36	12	<.001	4.04
Superior temporal gyrus	L	–	52	–36	12	.002	3.20
Superior temporal sulcus	R	–	50	–50	24	.002	3.04
Inferior frontal triangularis	L	1234	–44	28	–4	<.001	4.02
Inferior frontal triangularis	L	–	–28	26	–12	<.001	3.86
Inferior frontal gyrus	L	–	–36	18	30	.001	3.43
Lateral occipital gyrus	R	459	–22	–90	2	<.001	3.67
Lateral occipital gyrus	L	–	–12	–94	–2	.001	2.23
Inferior occipital gyrus	L	–	–38	–76	–6	.004	2.84
Pole of middle temporal gyrus	L	45	–46	4	–28	<.001	3.66
Middle temporal gyrus	L	–	–50	–4	–30	.003	2.99
Sagittal stratum	L	45	–32	–18	–6	.001	3.55
Fornix	L	–	–28	–10	–8	.004	2.88
Amygdala	R	471	22	–2	–10	.001	3.54
Inferior fronto-occipital fasciculus	R	–	32	2	–10	.001	3.49
Superior temporal gyrus	R	–	50	–10	–12	.001	3.28
Latero fronto-orbital gyrus	R	565	42	22	18	.001	3.49
Inferior frontal gyrus pars orbitalis	R	–	36	18	22	.002	3.06
Middle frontal gyrus	R	–	40	12	36	.004	2.84
Midbrain	R	44	0	–34	–6	.001	3.40
Midbrain	L	44	–6	–30	4	.001	3.34
Middle occipital gyrus	R	352	26	–78	–6	.001	3.33
Middle occipital gyrus	R	–	32	–82	–2	.001	3.32
Fusiform gyrus	R	–	20	–84	–12	.003	2.93
Angular gyrus	L	446	–54	–50	40	.001	3.23
TPJ – angular/supramarginal gyrus	L	–	–46	–54	26	.003	2.97
TPJ – angular/supramarginal gyrus	L	–	–60	–46	32	.003	2.91
Ventral striatum	L	198	–16	4	18	.002	3.19
Thalamus	R	–	–8	0	2	.002	3.10
Thalamus	R	–	4	–12	10	.010	2.43
Posterior corona radiata	L	48	–24	–48	32	.002	3.11
Posterior limb of internal capsule	R	125	28	–18	12	.002	3.09
Caudate nucleus	R	–	16	–16	2	.012	2.36
Pole of superior temporal gyrus	L	52	–36	2	–20	.002	3.07
Precuneus	L	332	–10	–50	32	.003	3.01
Posterior cingulate gyrus	L	–	–8	–30	32	.004	2.89
Precuneus	L	–	–12	–42	36	.004	2.88
Fusiform gyrus	R	14	36	–38	–20	.003	2.90

**Table 5 (continued)**

Region	H	Cs	Peak MNI Coordinate			Peak <i>p</i> -value	Peak <i>t</i> -value
			X	Y	Z		
Superior frontal gyrus	L	78	–8	54	18	.004	2.86
Body of corpus callosum	L	32	–2	4	26	.004	2.83
Posterior middle temporal gyrus	L	52	–48	–30	0	.004	2.81
Superior temporal gyrus	L	–	–44	–22	–4	.011	2.40
Fornix (column and body)	R	89	6	–26	16	.004	2.81
Fornix/Stria terminalis	R	–	20	–30	12	.013	2.34
Amygdala	L	21	–18	–6	–16	.004	2.81
Superior longitudinal fasciculus	L	11	–38	–40	6	.005	2.72
Posterior cingulate gyrus	R	81	14	–40	34	.005	2.71
Precuneus	R	–	12	–52	30	.007	2.61
Mid occipital gyrus	L	11	–32	–60	22	.006	2.69
Angular gyrus	L	55	–42	–70	38	.006	2.69
Mid occipital gyrus	L	–	–34	–74	40	.006	2.64
Hypothalamus	R	28	4	–10	–8	.006	2.69
Midbrain	L	–	–2	–14	–4	.011	2.42
Fusiform gyrus	R	34	40	–54	–12	.007	2.63
Fusiform gyrus	R	–	42	–52	–20	.019	2.17
Precentral gyrus	R	147	46	4	46	.007	2.58
Postcentral gyrus	R	–	42	–10	44	.009	2.48
Superior parietal gyrus	R	31	18	–36	58	.008	2.57
Superior frontal gyrus	L	16	–22	0	46	.009	2.52
Fusiform gyrus	L	36	–36	–62	–10	.009	2.49
Angular gyrus	L	71	42	–62	20	.009	2.49
Mid occipital gyrus	R	–	28	–58	26	.026	2.02
Precuneus	L	27	–10	–54	48	.010	2.44
Mid occipital gyrus	R	16	40	–76	22	.011	2.41
Posterior cingulate gyrus	L	10	–4	–56	–18	.011	2.41
Posterior cingulate gyrus	R	56	4	–52	14	.011	2.39
Superior cerebellar peduncle	R	22	10	–38	–22	.012	2.37
Angular gyrus	R	14	28	–46	36	.013	2.34
Cerebellum	R	12	6	–52	–40	.014	2.30
Caudate nucleus	L	14	–8	16	0	.016	2.25
Precuneus	L	17	–2	–54	42	.018	2.18
Superior frontal gyrus	R	11	28	24	56	.019	2.17
Cerebellum	R	11	4	–50	–2	.019	2.16

Note. H = hemisphere (L = left, R = right, B = bihemispheric). Cs = cluster size.

would be higher to ToM and factual reasoning questions following emotionally neutral than negative videos (Hypothesis 3).

On the neural level, we predicted that activity in response to the emotionally negative vs emotionally neutral videos would replicate activation in the AI, ACC and IFG (Hypothesis 4). We further anticipated that activity would largely overlap in response to empathy and compassion, but that some key differences would be visible. Specifically, we predicted that activity in the AI would be uniquely related to empathy, but not compassion (Hypothesis 5), and that activity in the ventral striatum would be uniquely related to compassion, but not empathy (Hypothesis 6). We hypothesised that activity in response to ToM vs non-ToM questions would replicate in the TPJ, TP, precuneus, and MPFC (Hypothesis 7). It was also predicted that activity in response to emotionally negative (vs neutral) videos compared to that in response to ToM (vs non-ToM) questions would replicate in the AI, ACC and IFG (Hypothesis 8) and activity in response to ToM (vs non-ToM) questions compared to activity in response to emotionally negative (vs neutral) videos would replicate in the TPJ, TP, precuneus, and MPFC (Hypothesis 9).

**Table 6**

Neural activity observed during the ROI analyses related to the parametric compassion ratings during videos.

Region	H	Replicated	Peak <i>p</i> -value	Peak <i>t</i> -value	CsG	CsE
Precuneus	L	No	0.245	3.01	474	641
TPJ - angular/ supramarginal gyrus	L	No	0.186	3.23	499	569
Middle frontal	L	Yes	0.045	4.02	537	770
SMA	L	Yes	0.031	4.21	595	1275
Cerebellum	R	No	voxels	–	120	–
TPJ - angular gyrus	L	No	0.182	3.04	316	323
Inferior frontal triangularis	R	No	0.325	2.60	251	187
Inferior orbitofrontal	L	Yes	0.007	3.86	36	41
Lingual	L	No	voxels	–	43	–
Cerebellum	L	No	voxels	–	70	–
Ventral striatum	L	Yes	0.041	3.10	45	65
Cerebellum	B	No	voxels	–	16	–
Ventral striatum	R	Yes	0.002	3.53	10	3

Note. H = hemisphere (L = left, R = right, B = bihemispheric). CsG = cluster size in number of voxels in the German validation of the paradigm. CsE = cluster size in number of voxels in the English version of the paradigm, assessed during the present experiment.

9), following the same pattern of activity observed in response to the original German version of the EmpaToM task (Kanske et al., 2015).

## 2. Method

### 2.1. Participants

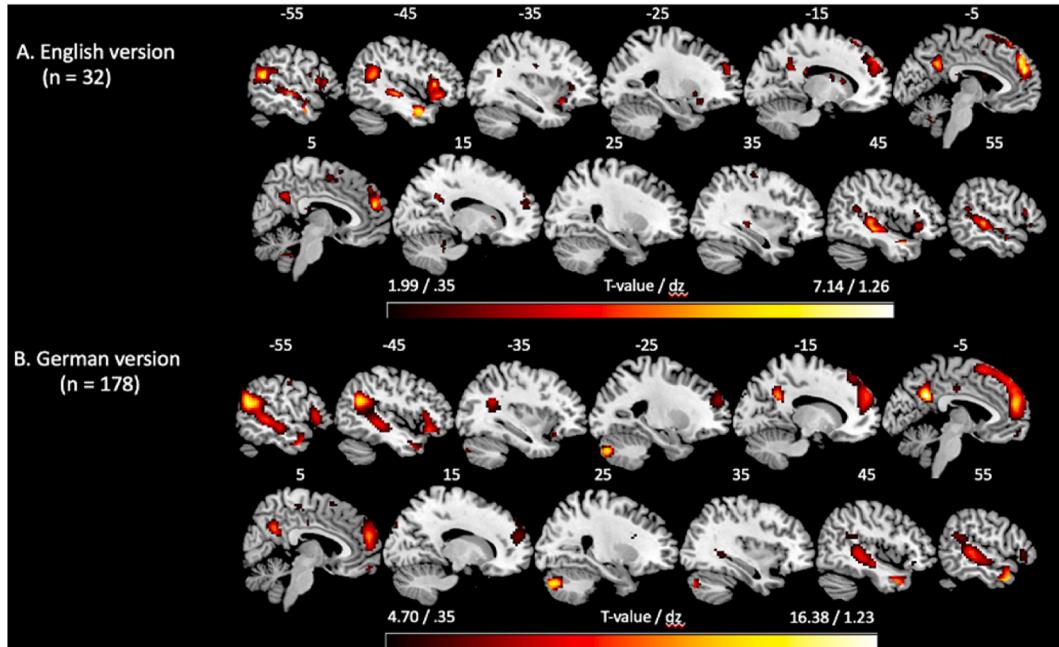
Thirty-two participants between the ages 18 and 65 (15 females: ages 21–65,  $M = 33.53$ ,  $SD = 13.19$  and 17 males: ages 18–46,  $M = 29$ ,  $SD =$

8.65; overall age:  $M = 31.13$ ,  $SD = 11.07$ ) were recruited to take part in the study via online advertisement. All participants spoke English as their first language. Upon indicating their interest, participants were interviewed via telephone to ensure that they had no MRI contraindications. After arriving to the laboratory, all participants were once again thoroughly interviewed by a qualified radiographer for MRI safety criteria before beginning the experiment. Participants were reimbursed with 50AUD for their time. Ethical approval was granted by the University of Melbourne Psychology Health and Applied Sciences Human Ethics Committee and all participants gave written consent to partaking.

To estimate the sample size necessary for running the study, we conducted an a priori power analysis based on data from the manuscript introducing the EmpaToM task (Kanske et al., 2015) using G\*Power (Faul et al., 2007, 2009). This manuscript lists three key regions of interest (ROIs) in relation to each of the two key hypotheses, including the MPFC, left TPJ, and right TPJ that were more active during the ToM condition, and the left AI, right AI, and dorsal ACC that were more active during the empathy condition. The effect size (Cohen's  $d_z$ ) was computed based on these brain regions using the formula: (Lakens, 2013). Specifically, we used the lowest *t* value of those regions ( $t = 7.97$ ) and the square root of Kanske et al.'s total sample size ( $N = 178$ ; 2015). This way, the effect size was determined as  $d_z = 0.597$ . We conducted the analysis for a paired, one-tailed *t*-test, using an alpha of 0.0167 (adjusted for multiple comparisons). The results revealed that a minimum sample of 28 participants would be necessary to achieve a power of .80. We oversampled to account for any potential issues with image quality.

### 2.2. Stimuli design

Two parallel versions of the EmpaToM task were re-created, each containing a set of 48 videos. Both sets contained 12 videos corresponding to each experimental condition (i.e., negative emotionality + ToM; negative emotionality + non-ToM; neutral emotionality + ToM; neutral emotionality + non-ToM). A total of 24 English-speaking actors



**Fig. 5.** Neural Activation Across the ToM > Non-ToM Questions Contrast in Response to A) the English EmpaToM Task, as Assessed in the Present Experiment, and to B) the German EmpaToM Task, as Assessed During the Original Validation of the Paradigm  
Note. Results are displayed on sagittal slices of the ch2better template using MRIcron. Numbers above each slice represent MNI coordinates. The colour continuum bar below the slices indicates the intensity/effect of the neural activation from lowest intensity/effect to highest intensity/effect. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

**Table 7**

Neural activity observed whilst responding to ToM &gt; Non-ToM questions.

Region	H	Cs	Peak MNI Coordinate			Peak <i>p</i> -value	Peak <i>t</i> -value
			X	Y	Z		
Temporal Pole	R	1187	50	2	-24	<.001	7.14
Posterior Superior Temporal Gyrus	-	-	48	-30	-4	<.001	5.63
Middle Superior Temporal Gyrus	-	-	44	-18	-8	<.001	4.38
Temporal Pole	L	1828	-48	0	-24	<.001	7.08
Posterior Superior Temporal Gyrus	-	-	-52	-52	18	<.001	7.07
Temporal Pole	-	-	-48	-6	-32	<.001	6.24
Dorsomedial Frontal Gyrus	B	1750	4	52	22	<.001	7.04
Dorsomedial Frontal Gyrus	-	-	-4	54	26	<.001	6.83
Dorsomedial Frontal Gyrus	-	-	-6	48	36	<.001	6.72
Inferior Frontal Gyrus	L	1279	-48	20	8	<.001	5.75
Inferior Frontal Gyrus	-	-	-42	26	-2	<.001	5.12
Inferior Frontal Gyrus	-	-	-50	14	14	<.001	4.44
– Pars Opercularis							
Precuneus	B	684	-2	-52	32	<.001	5.69
Precuneus	-	-	12	-50	32	<.001	3.79
Precuneus	-	-	22	-52	32	.018	2.19
Superior Frontal Gyrus	B	544	-10	34	58	<.001	5.20
Superior Frontal Gyrus	-	-	-10	24	58	<.001	4.02
Supplementary Motor Area	-	-	-6	8	66	.002	3.09
Corpus Callosum	L	28	-14	-32	22	<.001	4.05
Mid Cingulate Gyrus	B	95	0	-16	42	<.001	3.89
Cerebellum	B	128	4	-48	-38	<.001	3.71
Cerebellum	-	-	-4	-58	-38	.003	2.97
Cerebellum	-	-	16	-44	-28	.011	2.39
Orbitofrontal Gyrus	R	307	44	26	-4	<.001	3.65
Inferior Frontal Gyrus	-	-	54	20	14	.001	3.28
– Pars Opercularis							
Inferior Frontal Gyrus	-	-	48	24	10	.011	2.42
– Pars Triangularis							
Corpus Callosum	B	92	12	-28	20	.002	3.11
Corpus Callosum	-	-	0	-30	18	.003	2.92
Inferior Frontal Gyrus	L	34	-58	4	22	.002	3.07
Caudate	R	18	14	16	6	.003	2.92
Hippocampus	L	18	-30	-10	-16	.005	2.77
Precentral Gyrus	R	75	36	-18	58	.008	2.56
Precentral Gyrus	-	-	44	-14	60	.013	2.33
White Matter	L	17	-32	-14	30	.010	2.44
Thalamus	R	19	20	-18	8	.011	2.39
Cerebellum	L	24	-10	-36	-18	.017	2.21
Cerebellum	-	-	-2	-42	-12	.018	2.18

Note. H = hemisphere (L = left, R = right, B = bihemispheric). Cs = cluster size.

(12 actors in each version, with the gender of actors counterbalanced) were recruited to describe narrative events of their character's life. Each of the actors told one story belonging corresponding to each of the four experimental conditions. Participants were randomly assigned to observing only one of the two parallel versions of the task during the scanning session, whereas each participant was asked to practice the task before entering the scanner on the alternative version. All videos and scripts are available via the Open Science Framework (<https://osf.io/gfa3t/>). All videos as well as subsequent questions were displayed to participants using Presentation® software (Neurobehavioral Systems, Inc., Berkeley, CA, [www.neurobs.com](http://www.neurobs.com)).

### 2.3. Procedure

The experiment took place at the Melbourne Brain Centre on the University of Melbourne campus. Upon arrival to the laboratory, a trained radiographer interviewed participants to ensure compliance

**Table 8**

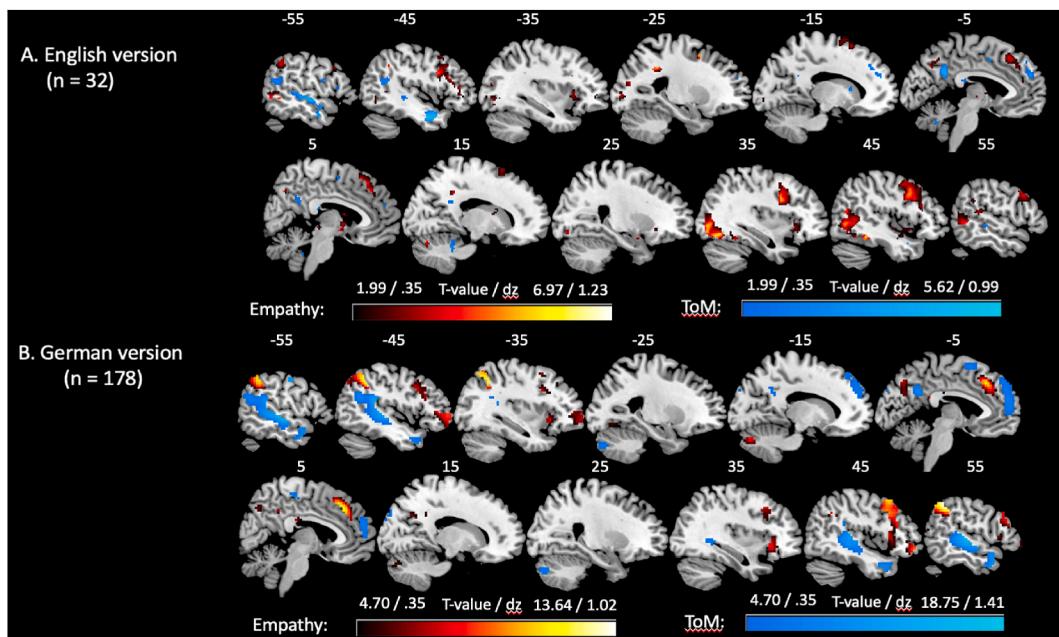
Neural activity observed during the ROI analyses related to the ToM &gt; Non-ToM questions.

Region	H	Replicated	Peak <i>p</i> -value	Peak <i>t</i> -value	CsG	CsE
Superior Medial Frontal/Superior Frontal Cortex	B	Yes	<.001	7.04	1185	1810
TPJ-Angular Gyrus/Middle Temporal/Superior Temporal	L	Yes	<.001	7.07	1019	1627
TPJ-Middle Temporal/Superior Temporal/Angular Gyrus	R	Yes	.002	5.63	640	945
Posterior Cingulate/Precuneus	B	Yes	.001	5.69	328	662
Inferior Frontal Gyrus	L	Yes	<.001	5.75	226	378
Cerebellum	R	No	No voxels	–	145	–
Temporal Pole	R	Yes	<.001	7.14	121	8
Cerebellum	L	No	No voxels	–	101	–
Temporal Pole	L	Yes	<.001	7.08	79	41
Inferior Frontal Gyrus	R	No	.154	2.67	52	28
Middle Cingulate	B	Yes	.009	3.89	50	105
Rectus	B	No	No voxels	–	38	–
Cuneus	R	No	No voxels	–	24	–
Postcentral Supplementary Motor Area	L	No	.181	1.89	13	1
Cuneus	B	No	No voxels	–	10	–

Note. H = hemisphere (L = left, R = right, B = bihemispheric). CsG = cluster size in number of voxels in the German validation of the paradigm. CsE = cluster size in number of voxels in the English version of the paradigm, assessed during the present experiment.

with MRI safety regulations. All participants signed an informed consent form. Prior to entering the scanner, an experimenter explained what the EmpaToM task entailed to participants, and asked them to practice the task on a laptop. This was to ensure that participants understood the task and to minimize the need to exclude any data acquired during the scanner task due to unfamiliarity with the experimental paradigm. None of the videos shown during the practice session were used during the scanner task. Participants were allowed to engage with the practice task until they felt comfortable with the paradigm.

As in the original EmpaToM task (Fig. 1), participants first saw a white fixation cross in the centre of a black screen, displayed for 1–3 s. Next, the name of a character was displayed for 2 s with white letters in the centre of a black screen. The scenario of the respective character describing an alleged autobiographic narrative was then played. These videos lasted for approximately 15 s. After the video, participants were shown the question 'How do you feel?'. They had 4 s to respond by moving a slider (coded from 0 to 720, numbers not shown to the participants) across a horizontal scale labelled negative at its far left side (0), neutral in the centre (360), and positive at its far right side (720). Responses to this question were used as a behavioural index of empathy. Participants were next presented with the question 'How much compassion do you feel?'. They again had 4 s to respond using a similar horizontal slider labelled none at the far left side (0) and very much at the far right side (720). Responses to this question were used as a behavioural index of compassion. This was followed by a 1–3 s long break where participants saw a black screen with a white fixation cross at the centre. A ToM (following videos containing ToM information) or factual reasoning question (following videos containing non-ToM information) was next presented in a multiple-choice design, with three response options labelled a, b, and c. Participants had up to 14 s to pick one of the options. After selecting an option, it remained visible on the screen for 1



**Fig. 6.** Neural Activation Across the Empathy Contrast > ToM Contrast and ToM Contrast > Empathy Contrast Observed in the A) English EmpaToM Task, as Assessed in the Present Experiment, and the B) German EmpaToM Task, as Assessed During the Original Validation of the Paradigm  
Note. Results are displayed on sagittal slices of the *ch2better* template using MRIcron. Numbers above each slice represent MNI coordinates. The colour continuum bar below the slices indicates the intensity (effect) of the neural activation from lowest intensity/activity to highest intensity/activity for empathy (black to white) and ToM (deep blue to light blue). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

s. This was followed by a white fixation cross presented in the centre of a black screen, displayed for 0–2 s. Finally, participants were presented with the questions ‘How confident do you feel?’, reflecting on their previous response on the multiple-choice question. They once again had 4 s to use a horizontal slider to indicate their response. The slider was labelled uncertain at the far left side (0) and certain on the far right side (720). The centre of each slider used throughout the experiment was indicated with a small line to make it easier for participants to visually navigate their responses. Participants were allowed to continue with the scenarios during the practice session until they felt comfortable with them, whereas during the scanner task, the same trial structure was repeated until the complete task set was displayed to participants.

Upon entering the scanner, participants were given MRI compatible headphones. These allowed them to listen to the scenarios whilst at the same time minimized the noise created by the scanner. Inside the scanner, participants used a button box to navigate their responses on the slider tasks and multiple-choice questions. Participants were able to communicate with the experimenter and radiographer in-between each scan. They were given a panic button to press in case they experienced any unforeseen issues. A 5-min long structural scan was acquired before the functional scans. Following the experiment, all participants were thoroughly debriefed and thanked for their time.

#### 2.4. Image acquisition

A 7T Magnetom system (Siemens Healthcare, Erlangen, Germany) with a 32-channel head-coil (Nova Medical Inc, Wilmington MA, USA) was used to acquire brain images. First, a 5-min long scan was conducted to acquire a T1-weighted whole brain structural image for anatomical reference, using 1.00 mm isotropic resolution, repetition time (TR) = 5290 ms, echo time (TE) = 2.8 ms, inversion time (TI) 1 = 700 ms, flip angle (FA) 1 = 8°, TI2 = 2700 ms, FA2 = 10°.

The functional images were acquired using a gradient echo planar imaging (EPI) multi-band sequence, with parallel imaging acceleration. A total image acceleration factor of 12 (two by parallel and six by multi-band) and blipped-controlled aliasing was used to achieve whole brain

coverage with 1.6 mm isotropic spatial resolution, and a temporal resolution of 800 ms with 3000 repetitions. Field of view (FOV) = 208 mm, TE = 22.2 ms, and fractional anisotropy = 45° were specified. The phase encoding direction was chosen to be posterior to anterior orientation to avoid signal pile up in the frontal cortex.

#### 2.5. Pre-processing of the fMRI data

Statistical Parametric Mapping (SPM12) software (Wellcome Trust Centre for Neuroimaging, 2009) run through Matlab software (Mathworks, R2014a) was used to conduct the pre-processing and statistical analysis of the imaging data. First, to correct for head movement artefacts, all EPI images were realigned to the first scan of each functional run through affine transformation. Second, the T1-weighted anatomical image was co-registered to the mean functional image created during realignment. Third, to counter the variations in brain size and anatomy among participants, the T1 structural scans were normalised to the MNI (Montreal Neuropsychological Institute) standard T1 template with a voxel size of 1 × 1 × 1 mm. Fourth, the same normalisation parameters were then used to normalise the functional images (with a voxel size of 2 × 2 × 2 mm). This mathematical transformation process allows selected brain areas to be matched with the MNI template and standardised across all participants. In the final stage of data pre-processing, the normalised functional images were smoothed with an isotropic Gaussian kernel of 6 mm. The smoothing process is intended to average the brain signals by enhancing signals with low frequency and removing signals with high frequency.

#### 2.6. fMRI analyses

A general linear model was created for each participant during first-level analysis. An event-related design identified the voxels across the brain which showed significant Blood-Oxygen-Level-Dependent (BOLD) changes compared to the baseline for each participant, in each condition. The events were modelled with a canonical hemodynamic response function time-locked to the onset of each video clip and corresponding

**Table 9**

Neural activity observed in the empathy contrast &gt; ToM contrast.

Region	H	Cs	Peak MNI Coordinate			Peak p-value	Peak t-value
			X	Y	Z		
Fusiform Gyrus	R	1548	38	-46	-22	<.001	6.97
Fusiform Gyrus	-	-	38	-72	-14	<.001	6.74
Fusiform Gyrus	-	-	46	-42	-16	<.001	5.39
Middle Frontal Gyrus	R	1348	40	10	38	<.001	6.51
Precentral Gyrus	-	-	38	4	32	<.001	6.24
Precentral Gyrus	-	-	40	-2	46	<.001	4.79
Posterior Inferior Temporal Gyrus	L	160	-58	-52	-6	<.001	6.11
Posterior Middle Temporal Gyrus	-	-	-50	-54	4	.001	3.50
Inferior Parietal Lobule	L	60	-28	-46	34	<.001	5.61
White Matter	-	-	-22	-36	32	.023	2.08
Posterior Superior Temporal Gyrus	R	177	64	-34	14	<.001	5.59
Posterior Superior Temporal Gyrus	-	-	56	-38	14	<.001	3.83
Inferior Frontal Gyrus – Pars Triangularis	L	607	-44	42	10	<.001	5.11
Precentral Gyrus	-	-	-44	10	30	<.001	4.44
Inferior Frontal Gyrus – Pars Triangularis	-	-	-44	24	22	<.001	3.84
Middle Frontal Gyrus	L	24	-26	8	50	<.001	5.08
Inferior Parietal Lobule	L	112	-48	-48	40	<.001	4.74
Cerebellum	R	27	10	-74	-24	<.001	4.54
Superior Medial Frontal Gyrus (Including Dorsal Anterior Cingulate Cortex)	B	577	2	26	50	<.001	4.43
Superior Medial Frontal Gyrus	-	-	2	32	44	<.001	4.13
Superior Medial Frontal Gyrus	-	-	4	38	36	.003	3.02
Mid Occipital Gyrus	L	47	-30	-78	18	<.001	4.35
Caudate	R	54	10	4	12	<.001	4.00
Caudate	-	-	12	10	18	.008	2.53
Hypothalamus	B	87	4	-2	-8	<.001	4.00
Caudate	-	-	6	2	0	.001	3.49
White Matter	-	-	-4	0	0	.008	2.57
White Matter	R	17	32	2	-14	<.001	3.76
Superior Frontal Gyrus	L	150	-18	6	70	<.001	3.71
Superior Frontal Gyrus	-	-	-16	14	64	<.001	3.65
Precuneus	B	118	-4	-70	38	<.001	3.70
Precuneus	-	-	6	-68	40	.001	3.45
Precuneus	-	-	-4	-68	46	.002	3.18
Posterior Cingulate Gyrus	R	29	10	-44	40	<.001	3.66
Middle Occipital Gyrus	L	227	-38	-78	-2	<.001	3.65
Middle Occipital Gyrus	-	-	-28	-88	0	.001	3.53
Cuneus	-	-	-20	-90	6	.001	3.30
Anterior Insula	L	75	-32	20	4	<.001	3.64
Anterior Insula	-	-	-32	24	-4	.001	3.28
Supplementary Motor Area	R	62	16	16	66	.001	3.34
Anterior Insula	R	313	38	20	-2	.002	3.21
Anterior Insula	-	-	42	-2	-18	.002	3.19
Anterior Insula	-	-	28	22	-6	.003	2.90
Brainstem	B	36	10	-24	-4	.002	3.03
Brainstem	-	-	0	-26	-4	.006	2.67
Middle Temporal Gyrus	R	11	66	-32	-6	.003	2.97
Thalamus	B	22	-6	-12	0	.004	2.86
Middle Frontal Gyrus	L	39	-46	14	50	.004	2.84
Middle Frontal Gyrus	-	-	-40	10	58	.005	2.77
Supramarginal Gyrus	R	24	58	-44	32	.005	2.74
Superior Medial Frontal Gyrus	L	16	-8	44	20	.006	2.68
Superior Temporal Gyrus (Mid)	R	10	46	-10	-6	.009	2.50
Superior Temporal Gyrus (Mid)	L	15	-42	-12	-10	.014	2.32

Note. H = hemisphere (L = left, R = right, B = bihemispheric). Cs = cluster size.

**Table 10**

Neural activity observed during the ROI analyses related to the empathy contrast &gt; ToM contrast.

Region	H	Replicated	Peak p-value	Peak t-value	CsG	CsE
Middle Frontal (Including Anterior Insula, Inferior Frontal Operculum and Inferior Orbitofrontal)	R	Yes	.001	5.83	424	660
Superior Medial Frontal (Including Anterior Cingulate)	B	Yes	.012	4.43	235	616
TPJ-Angular/ Supramarginal Gyrus	L	Yes	.002	5.25	217	418
Middle Frontal/Inferior Frontal Gyrus/Inferior Frontal Triangularis	L	Yes	.012	4.18	155	103
TPJ-Angular/ Supramarginal Gyrus	R	Yes	.008	4.36	115	179
Middle Frontal (Including Inferior Frontal Triangularis)	L	Yes	.022	3.93	108	218
Cuneus/Precuneus	B	Yes	.013	4.13	107	258
Anterior Insula	L	Yes	.044	3.28	58	64
Cerebellum	L	Yes	.001	4.27	45	13
Fusiform Gyrus	L	No	.215	2.11	32	13
Cerebellum	R	Yes	.001	4.29	32	9
Middle Cingulate	B	No	–	24	–	–
Precuneus	B	Yes	.008	3.66	13	36

Note. H = hemisphere (L = left, R = right, B = bihemispheric). CsG = cluster size in number of voxels in the German validation of the paradigm. CsE = cluster size in number of voxels in the English version of the paradigm, assessed during the present experiment.

question (for each of the four conditions) with a duration equal to the duration of the video clip or response time to the question. In addition, the valence, compassion, and confidence ratings were similarly modelled with the onset time-locked to the start of the question and the duration equal to the response time. All events were modelled together with a time derivative to allow for subject-to-subject and voxel-to-voxel variation in the timing of the peak of the hemodynamic response function. Parametric modulation was performed for both the valence and compassion ratings.

During the second-level analyses the contrast images for the emotionally negative > emotionally neutral videos (empathy contrast) were compared with one-sample t-tests. A one-sample t-test was conducted for the empathy and compassion contrasts using the parametric modulation conducted at the first level. The contrast images for the ToM questions > non-ToM questions (ToM contrast) were also compared with one-sample t-tests. To test whether the empathy and ToM contrasts resulted in different neural activity, we conducted paired sample-tests comparing the empathy contrast with the ToM contrast (empathy contrast > ToM contrast, ToM contrast > empathy contrast), whilst using the significant results from the respective one-sample t-tests as an inclusive mask. These allowed us to explore the unique neural responses related to empathy and ToM.

Results were thresholded at the same effect size as the original analysis using the formula  $dz = t/\sqrt{n}$  (Lakens, 2013). This resulted in all analyses being thresholded at  $t = 1.99$  (minimum cluster size = 10), which corresponded to an effect size of  $dz = 0.35$ . To further investigate which of the significant clusters observed during the validation of the German EmpaToM task replicated in the English EmpaToM version, ROI analyses (thresholded at  $p = .05$  uncorrected) were conducted for each of the clusters in each of the analyses (with significance defined as FWE  $p < .05$  and marginal significance defined as FWE  $p < .10$  corrected for the size of the original cluster).

**Table 11**

Neural activity observed in the ToM &gt; empathy contrast.

Region	H	Cs	Peak MNI Coordinate			Peak <i>p</i> -value	Peak <i>t</i> -value
			X	Y	Z		
Temporal Pole	L	520	-50	-2	-26	<.001	5.62
Middle Temporal Gyrus	-	-	-56	-10	-4	<.001	5.33
Superior Temporal Gyrus	-	-	-56	-18	-2	<.001	4.29
Precuneus	B	279	-4	-52	32	<.001	4.59
Posterior Cingulate Gyrus	-	-	8	-50	28	.006	2.65
Inferior Frontal Gyrus/ Precentral Gyrus	L	28	-58	2	24	<.001	3.91
Caudate	L	52	-16	14	10	<.001	3.72
Putamen	-	-	-20	14	-2	.003	2.99
Dorsomedial Prefrontal Cortex	B	224	-8	52	26	<.001	3.68
Superior Frontal Gyrus	-	-	-20	46	20	.003	2.92
Superior Frontal Gyrus	-	-	-10	48	42	.005	2.71
Cerebellum	B	55	10	-44	-36	<.001	3.68
Cerebellum	-	-	16	-44	-28	.001	3.24
Cerebellum	-	-	-2	-46	-38	.010	2.47
Temporal Pole	R	17	48	6	-24	<.001	3.65
Supplementary Motor Area	B	17	-4	2	46	.001	3.24
Mid Cingulate Gyrus	B	20	-2	-10	40	.002	3.12
Temporoparietal Junction	L	180	-50	-52	20	.002	3.08
Corpus Callosum	B	59	0	-30	16	.002	3.07
Cerebellum	L	11	-6	-62	-30	.003	2.89
Supplementary Motor Area	B	36	-4	-4	56	.003	2.89
Supplementary Motor Area	-	-	8	-4	56	.007	2.60
Middle Temporal Gyrus	R	30	52	-32	-4	.011	2.42
Inferior Frontal Gyrus – Pars Triangularis	L	16	-40	26	2	.013	2.35
Inferior Frontal Gyrus – Pars Triangularis	L	11	-52	20	10	.014	2.30

Note. H = hemisphere (L = left, R = right, B = bihemispheric). Cs = cluster size.

**Table 12**

Neural activity observed during the ROI analyses related to the ToM contrast &gt; empathy contrast.

Region	H	Replicated	Peak <i>p</i> -value	Peak <i>t</i> -value	CsG	CsE
TPJ/Superior Temporal/ Planum Temporal/ Angular Gyrus	L	Yes	.004	5.39	692	701
Superior Temporal	R	No	.556	2.60	393	121
Superior Frontal (Including Superior Medial Frontal)	B	Marginal	.100	3.68	386	188
Temporal Pole	R	Yes	.002	3.65	117	5
Posterior Cingulate/ Precuneus	B	Yes	.004	4.59	93	225
Temporal Pole	L	Yes	<.001	5.56	72	30
Cerebellum	R	No	No voxels	-	41	-
Supplementary Motor Area	B	No	No voxels	-	34	-
Cerebellum	L	No	No voxels	-	27	-
Superior Occipital	R	Marginal	.054	2.42	24	3
Postcentral	L	No	.155	2.01	13	11
Supplementary Motor Area	R	No	No voxels	-	10	-

Note. H = hemisphere (L = left, R = right, B = bihemispheric). CsG = cluster size in number of voxels in the German validation of the paradigm. CsE = cluster size in number of voxels in the English version of the paradigm, assessed during the present experiment.

### 3. Results

#### 3.1. Behavioural results

##### 3.1.1. Hypothesis 1 (valence ratings)

We tested the internal consistency of the empathy assessment. We reverse scored the responses to all emotionally neutral videos to do so. The results revealed that the measure is reliable in both of its parallel versions (Cronbach's  $\alpha_1 = 0.95$ , Cronbach's  $\alpha_2 = 0.87$ ).

Participants reported feeling more negative following emotionally negative (empathy) videos ( $M = 170$ ,  $SD = 73$ , 95% CI [143, 196]) compared to neutral (no empathy) videos ( $M = 381$ ,  $SD = 58$ , 95% CI [360, 402]). The magnitude of the difference between these means ( $M_{diff} = 211$ , 95% CI [172, 250]) was significant ( $t(31) = 11.03$ ,  $p < .001$ , two-tailed). In standardised terms, this effect size was large according to Cohen's (1988) guidelines ( $d_{unbiased} = 3.13$ , 95% CI [2.22, 4.17]).

##### 3.1.2. Hypothesis 2 (compassion ratings)

We tested the internal consistency of the compassion assessment. We reverse scored the responses to all emotionally neutral videos to do so. The results revealed that the measure is reliable in both of its parallel versions (Cronbach's  $\alpha_1 = 0.81$ , Cronbach's  $\alpha_2 = 0.88$ ).

Participants reported feeling more compassion following emotionally negative videos ( $M = 529$ ,  $SD = 102$ , 95% CI [492, 566]) compared to neutral videos ( $M = 289$ ,  $SD = 98.92$ , 95% CI [253, 325]). The magnitude of the difference between these means ( $M_{diff} = 240$ , 95% CI [200, 280]) was significant ( $t(31) = 12.23$ ,  $p < .001$ , two-tailed). In standardised terms, this effect size was large in size according to Cohen's (1988) guidelines ( $d_{unbiased} = 2.33$ , 95% CI [1.68, 3.08]).

##### 3.1.3. Hypothesis 3 (ToM performance)

As predicted, accuracy was significantly higher following videos which included neutral ( $M = 0.58$ ,  $SE = 0.03$ , 95% CI [0.53, 0.64]) vs negative emotionality ( $M = 0.53$ ,  $SE = 0.03$ , 95% CI [0.47, 0.59]),  $F(1, 31) = 6.00$ ,  $p = .02$ ,  $\eta^2 = 0.16$ . Accuracy to ToM ( $M = 0.55$ ,  $SE = 0.02$ , 95% CI [0.51, 0.60]) and factual questions ( $M = 0.56$ ,  $SE = 0.03$ , 95% CI [0.50, 0.63]) was not influenced by the ToM content of the stimuli,  $F(1, 31) = 0.10$ ,  $p = .75$ ,  $\eta^2 = 0.003$ . There was no interaction across the conditions in response accuracy,  $F(1, 31) = 0.54$ ,  $p = .47$ ,  $\eta^2 = 0.02$ .

#### 3.2. fMRI results

##### 3.2.1. Hypothesis 4 (emotional minus neutral)

**Fig. 2** shows fMRI results of emotional minus neutral videos from the English version of the EmpaToM task (top "A") compared with the fMRI results from the original German version of the EmpaToM task (bottom "B"). As is clear from **Fig. 2**, the empathy contrast results between the English EmpaToM task and German version are similar. **Table 1** provides an overview of all brain regions that survived the threshold presented in **Fig. 2A**. To further test which of the 14 brain regions from the original Kanske et al. (2015) study in this contrast replicated, ROI analyses were conducted as described in the methods section. **Table 2** shows data of the 14 clusters with their corresponding cluster size, peak *p*-values, and peak *t*-values. The first seven listed brain regions (**Table 2**) were the large clusters and ROI analyses revealed that these larger clusters all replicated including areas typically associated with empathy such as the AI, ACC and IFG, with six showing significance and one marginal significance. The last listed seven brain regions (**Table 2**) were smaller clusters and included regions not typically associated with empathy such as the lingual gyrus, middle temporal cortex, middle cingulate, and middle occipital gyrus. Of these, two replicated. Further details of these data (including the output data from SPM) are provided on OSF. These results support Hypothesis 4.

### 3.2.2. Hypothesis 5 (unique empathy-related activity)

**Fig. 3** displays the fMRI data for the parametric empathy ratings during videos, for the English-speaking and German-speaking paradigms of the EmpaToM task. A visual inspection of **Fig. 3** indicates that the brain activation for participants during the English and the German-speaking EmpaToM tasks are alike for this condition. **Table 3** displays an overview of all clusters that survived the predetermined threshold, for the English-speaking paradigm of the EmpaToM task. As predicted by Hypothesis 5, the right AI shows unique activation here. Next, to confirm which clusters from the German-speaking paradigm were replicated in the current, English-speaking paradigm, ROI analyses were conducted. These ROI analyses are outlined in **Table 4**. Here, of the 10 ROIs, four replicated, whilst six did not replicate. Those that replicated included the right TPJ, supramarginal, angular gyrus, right cerebellum, right inferior orbitofrontal gyrus, IFG, and the medial superior frontal lobe. The left TPJ, angular, supramarginal gyrus, the left inferior orbitofrontal lobe, and IFG showed marginal significance. Those that did not replicate, included the left precuneus, left middle frontal, left cerebellum, and right middle cingulate.

### 3.2.3. Hypothesis 6 (unique compassion-related activity)

**Fig. 4** displays brain activation for the parametric compassion data during videos, for the English and German-speaking paradigms of the EmpaToM task. A visual inspection of **Fig. 4** indicates that the neural activation for participants during the English-speaking EmpaToM task and German-speaking EmpaToM task are alike. **Table 5** displays an overview of all clusters that survived the predetermined threshold, for the English-speaking paradigm of the EmpaToM task. In line with Hypothesis 6, unique activity is present in the ventral striatum. To determine which clusters from the German-speaking paradigm were replicated in the current, English-speaking paradigm, ROI analyses were conducted. The ROI analyses are outlined in **Table 6** and corroborate the unique ventral striatum activity. Here, of the 13 ROIs, five replicated, whilst eight did not replicate. Those that replicated included the left middle frontal, left supplementary motor area, left inferior orbitofrontal, left ventral striatum and right ventral striatum. Clusters that did not replicate included those in the left precuneus, left TPJ, angular and supramarginal gyrus, right inferior frontal triangularis, left lingual, and bilateral cerebellum.

### 3.2.4. Hypothesis 7 (ToM minus Non-ToM)

**Fig. 5** shows fMRI results of ToM minus non-ToM questions from the English version of the EmpaToM task (top “A”) compared with the fMRI results from the original German version of the EmpaToM task (bottom “B”). As is clear from **Fig. 5**, the ToM contrast results between the English EmpaToM task and German version are very similar. **Table 7** provides an overview of all brain regions that survived the threshold presented in **Fig. 5A**. **Table 8** shows data of the 16 clusters from the original [Kanske et al. \(2015\)](#) study with their corresponding cluster sizes, peak p-values, and peak t-values. The first eight listed brain regions (**Table 8**) are considered the large clusters. From these eight larger clusters, six replicated the original [Kanske et al. \(2015\)](#) publication including clusters typically associated with ToM such as the TPJ, TP, precuneus, and MPFC, and two did not. The two large clusters that did not replicate were located in the cerebellum, which is not typically associated with ToM. The last eight brain regions (**Table 8**) are smaller clusters also not typically associated with ToM. Of these, two replicated. These results support Hypothesis 7.

### 3.2.5. Hypothesis 8 (empathy contrast minus ToM contrast)

The results of the analyses investigating the empathy contrast > ToM contrast revealed a similar pattern of activation to those observed during the validation of the German EmpaToM task ([Kanske et al., 2015](#); see **Fig. 6**; **Table 9**). A ROI analysis confirmed that key activations in the AI, ACC and IFG replicated in the present experiment (**Table 10**). Activity in some smaller clusters encompassing the fusiform gyrus and the middle

cingulate cortex did not replicate (**Table 10**). These results support Hypothesis 8.

### 3.2.6. Hypothesis 9 (ToM contrast minus empathy contrast)

The results of the analyses investigating the ToM contrast > Empathy contrast revealed a similar pattern of activation to those observed during the validation of the German EmpaToM task ([Kanske et al., 2015](#); see **Fig. 6**; **Table 11**). A ROI analysis confirmed that key activations in the TPJ, TP, MPFC, and precuneus replicated in the present experiment (**Table 12**). Activity in some smaller clusters encompassing, e.g., the supplementary motor area, did not replicate (**Table 12**). These results support Hypothesis 9.

## 4. Discussion

This project introduced an English version of the EmpaToM task, a paradigm aiming to assess empathy, compassion, and ToM on the behavioural as well as neuronal level with one single task, which previously has only been validated in German language ([Kanske et al., 2015](#)). In doing so, we compared behavioural and neural results to those published in the original validation of the task. The findings suggest that the novel English version is reliable, as it replicates earlier results.

Specifically, the behavioural results indicate increased negative affect, that is empathy, after observing videos containing emotionally negative autobiographic narratives compared to emotionally neutral ones. This suggests that participants experienced a heightened sense of sharing the narrator's emotions and feeling states, while explicitly acknowledging that they originated from the actor in the video. Participants also reported increased levels compassion towards the narrator after observing emotionally negative versus neutral videos. This suggests that participants experienced feeling more warmth and concern as a result of the actors' suffering in the emotionally negative videos. These findings replicate the results observed in the original EmpaToM validation ([Kanske et al., 2015](#)).

In line with our predictions, we further replicated neural responses in the AI, ACC and IFG in the empathy condition whilst observing emotionally negative vs neutral videos ([Kanske et al., 2015](#)). The AI and ACC are strongly connected ([Allman et al., 2010](#)), and activity in these regions is related to the processing of both observed and experienced pain ([Corradi-Dell'Acqua et al., 2016](#); [Duerden and Albanese, 2013](#); [Lamm et al., 2011](#); [Singer et al., 2004](#)). Activity in the IFG has been related to emotion regulation via reappraisal, particularly with regards to social emotions ([Grecucci et al., 2013](#); [Ochsner et al., 2012](#)). These three regions have been reliably regarded as core components of the neural network of empathy and empathic processing ([Bzdok et al., 2012](#); [Corradi-Dell'Acqua et al., 2016](#); [Engen and Singer, 2013](#); [Eres et al., 2015](#); [Lamm et al., 2011](#); [Schurz et al., 2021](#); [Singer et al., 2004](#); [Tholen et al., 2020](#)).

Parametric modulation analyses further allowed us to differentiate the neural correlates of empathy and compassion, in line with the original validation of the EmpaToM task ([Kanske et al., 2015](#)). Notably, we observed activity in the right AI to be uniquely related to empathy. In contrast, we also observed activity in the ventral striatum to be uniquely related to compassion, an area linked to positive feelings associated with affiliation, connectedness and reward processing ([Báez-Mendoza and Schultz, 2013](#); [Cardinal et al., 2002](#)). The results are weaker than those reported by Kanske and colleagues, which is expected due to the reduced power caused by the smaller sample, as well as to the use of a 7T scanner which is more problematic for the imaging of subcortical structures than a 3T scanner used in the earlier validation studies. Nevertheless, these findings are in line with those previously observed showing a crucial role of ventral striatum, nucleus accumbens, and other reward-related areas in compassion ([Engen and Singer, 2015](#); [Klimecki et al., 2013, 2014](#)). Additionally, it is anticipated that the activity related to compassion may increase as a result of compassion training when participants learn to further differentiate between empathy and compassion

to avoid empathic distress (Klimecki et al., 2013, 2014; Singer and Engert, 2019; Trautwein et al., 2020; Valk et al., 2017).

We additionally replicated neural activation in the ventral TPJ, TP, MPFC, and precuneus whilst responding to ToM questions vs factual knowledge questions. These same regions remained significant across analyses comparing the empathy minus ToM contrast, and vice versa. The ventral TPJ, TP, MPFC, and precuneus play key roles in social cognition and ToM. The TPJ has been specifically associated with identifying and representing goals and intentions behind behaviour, whereas the MPFC has been further related to person perception and self-knowledge (Amodio and Frith, 2006; Van Overwalle, 2009). The TP has been linked to thinking about others' thoughts and emotions as well as inferring others' mental states, supporting its importance in ToM (Frith and Frith, 2003; Olson et al., 2007). Activity in the precuneus has been linked to self-processing tasks as well as shifting between first- and third-person perspectives (Cavanna and Trimble, 2006). These core regions make up the neural network of ToM (Bzdok et al., 2012; Frith and Frith, 2003, 2006; Kanske et al., 2015; Molenberghs et al., 2016; Schurz et al., 2021; Tholen et al., 2020). Thus, the present analyses indicate that empathy and ToM can be distinguished on the neural level using the English version of the EmpaToM task presented here.

ROI analyses further indicated that some smaller clusters observed during the original validation of the EmpaToM task (Kanske et al., 2015) were not replicated in the present analyses. These regions were small clusters with much smaller effect sizes in the original experiment and involved regions not readily implicated in empathic or mentalizing processes. This might indicate that earlier results might have been false positives or that the current study lacked enough power to replicate these smaller effects.

The findings presented here nevertheless have important implications for the research community as well as for clinicians. Introducing the English version of the EmpaToM task makes its use possible across English-speaking countries. Sharing all stimuli via the Open Science Framework allows the research community as well as clinicians to utilize the present version of the EmpaToM task in future work. We further encourage the translation of the EmpaToM task to other languages and the comparison of the results obtained using such versions to those observed in the original validation study. This way, the applicability of this task can be maximised internationally, whilst any cultural effects potentially influencing the results may be examined. The comparison of the results across diverse cultures (such as individualist vs collectivistic cultures) may be especially informative.

#### 4.1. The significance of fMRI replication

The study also adds to the growing literature aiming to replicate previously published studies in light of the replicability crisis in psychology and cognitive neuroscience (Lindsay, 2015; Open Science Collaboration, 2015). Given the costly nature of fMRI investigation (including financial costs, time commitments of participants as well as the research team, specialized personnel, MRI facilities, etc.), it is less common to publish replication studies using fMRI than behavioural data. The lack of replication studies available in the literature is further related to scientific journals aiming to publish novel findings, thus leading to an ethos which does not favour studies conducted with the aim of replicating previously published results. Nevertheless, such replication studies are crucial to establish trust in the field among scientists as well as the general public (Anvari and Lakens, 2018).

Neuroimaging research has been criticized and its replicability questioned due to features which increase the probability of false positive results, such as flexibility in the chosen analyses, lack of corrections for multiple comparisons, software errors, or the unwillingness to share stimuli, data or code necessary for replication (Bennett et al., 2009; Carp, 2012; Kriegeskorte et al., 2009; Lyon, 2017; Poldrack et al., 2017). The present results overlap with those observed during the original EmpaToM task and the respective publication (Kanske et al., 2015).

These findings not only indicate the reliability of the task, but also support the replicability of fMRI experiments more broadly.

#### 4.2. Limitations

The present experiment had a limited sample size. As a result, a complete replication of all analyses which may be conducted based on the neural data collected during the EmpaToM task was not feasible. Specifically, the present experiment did not account for the neural activity associated with metacognition in relation to one's social skills (Molenberghs et al., 2016), as the relevant analyses would have been underpowered. With the successful replication of other findings, it is reasonable to assume that given optimal power, these neural analyses would also produce a similar pattern of findings. We recommend that future research investigates this question further using the present paradigm in a larger sample.

Whereas the original validation of the EmpaToM task included the comparison of the results to other relevant tasks, such as the Samson Visual Perspective Taking Task (Samson et al., 2010) or the Saxe False Belief Task (Dodell-Feder et al., 2011; Kanske et al., 2015), the present validation of the English EmpaToM task omitted these. Given that the task itself has already been validated, here we were primarily interested in replicating the behavioural and neural results of the task. As we were able to replicate these, it is reasonable to assume that the original validation may apply to the task presented here as well. Nevertheless, any further studies testing the correlations between the EmpaToM task and further tasks related to empathy, compassion, and ToM are encouraged. Future research should also devote attention to examining the test-retest reliability of the task. While we did not have the resources to run a longitudinal study here, the two parallel versions of the task make such designs possible.

#### 5. Conclusions

Throughout this manuscript, we detailed the development and performance of an English language version of the EmpaToM task. While empathy, compassion, and ToM are related processes, the behavioural and neural data obtained with this task may contribute to further supporting their conceptual differentiation. By doing so, the EmpaToM task is especially useful in research endeavors aimed at identifying specific social cognition deficits in mental disorders, or distinguishing developmental patterns associated with socio-affective versus socio-cognitive processes, among other potential applications. The corresponding behavioural and neural data obtained from a sample of English-speaking participants was comparable to that previously reported using the original German task, tested among German-speaking participants. These results allow us to conclude that the English version of the paradigm can be used to assess empathy, compassion, and ToM. This tool may be a valuable extension of the original paradigm, as it allows its wider use across English-speaking populations.

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#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Data availability

The data and syntax is available via OSF. The link is included in the manuscript.

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