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„The bystander effect and its underlying neural mechanisms“

verfasst von

Florence Schmoll

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Betreuerinnen: Univ.-Prof. PD Dipl.-Psych. Dr. Kristina Hennig-Fast

„I think there is evidence that humans are capable of altruistic motives under certain circumstances.”

Charles Daniel Batson (born 1943)

“The world is a dangerous place to live; not because of the people who are evil, but because of the people who don't do anything about it.”

Albert Einstein (1879-1955)

„Ihr drängt euch um den Nächsten und habt schöne Worte dafür. Aber ich sage euch: eure Nächstenliebe ist eure schlechte Liebe zu euch selber. […]

Meine Brüder, zur Nächstenliebe rate ich euch nicht.“

Friedrich Nietzsche (1844-1900)

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ZUSAMMENFASSUNG

Ende des Jahres 2014 wurde ein 58-jähriger Mann tot in einem Lift im Wiener U-Bahn-System gefunden, nachdem er zuvor fünf Stunden lang mit Herzversagen gerungen hatte. Einer der zwölf Monitore in der Station zeichnete seinen lang andauernden Todeskampf, welchen vermutlich auch die diensthabenden Angestellten vom Überwachungsdienst in dieser Nacht verfolgt hatten, auf. Mehrere Personen haben den Lift, in welchem der schmerzleidende, unterstandslose Mann gelegen hat, benutzt. Erst als am nächsten Morgen eine Reinigungskraft den Mann entdeckte, wurde die Rettung alarmiert. Der Mann starb auf dem Weg zum Krankenhaus (Möseneder, 2015).

Der Bystander-Effekt bezeichnet das sehr gut etablierte psychologische Phänomen der sinkenden Wahrscheinlichkeit an Hilfestellung einem Opfer in Not gegenüber, mit der wachsenden Zahl an umstehenden Personen (engl.: *bystander*). Latané und Darley (1970) erklären die Entstehung dieses Effekts durch eine Verantwortungsdiffusion auf andere umstehende Personen durch eine Bewertungsangst, die durch die Befürchtung entsteht, von anderen verurteilt zu werden, nachdem eine Handlung gesetzt wurde, sowie durch pluralistische Ignoranz. Letztere unterdrückt kollektiv eine Handlungsmotivation, da die Situation als ambivalent wahrgenommen wird.

Während es unzählige Studien zum Bystander-Effekt aus sozial-psychologischer Sicht gibt (für eine Zusammenfassung siehe zum Beispiel Fischer et al., 2011), existieren zur Rolle des Gehirns in diesem spezifischen Setting nur sehr wenige wissenschaftliche Untersuchungen.
Eine Ausnahme bildet da die relativ neu veröffentlichte Studie von Hortensius und de Gelder aus dem Jahr 2014. Sie beschäftigten sich nicht nur mit dem empathischen neuronalen Netzwerk oder die Auswirkungen einer als ambivalent wahrgenommenen Situation auf das Gehirn, sondern spezifischer, mit dem klassischen Bystander-Effekt mit bis zu vier umstehenden Personen und einem Opfer in einer Notsituation. Durch das Scannen der Studienteilnehmer mit einem fMRI-Gerät waren die Autoren in der Lage, die zugrundeliegenden neurologischen Mechanismen, welche dieses moralisch

kontraintuitive Phänomen der unterlassenen Hilfeleistung beeinflussen, zu untersuchen.
Waren keine oder nur wenige Menschen in der Notsituation anwesend, waren der linke Gyrus prae- und postcentralis sowie der medial frontale Gyri signifikant aktiv. Diese Gehirnareale sind auch in empathischen Prozessen involviert. Im Gegensatz dazu löste ein Anstieg an umstehenden Personen eine erhöhte Aktivität in anderen Regionen aus. In dieser Bedingung wurde ein erhöhter Energieverbrauch im superioren okzipitalen Gyrus, dem rechten lingualen Gyrus, dem linken Cuneus und dem linken mittleren temporalen Gyrus festgestellt. Zusätzlich wurden jene Gehirnregionen aktiv, in welchen die visuelle Wahrnehmung und Aufmerksamkeit lokalisiert sind, genauso wie jene verantwortlich für die Initiierung einer Handlung. Hortensius und de Gelder (2014) kamen zu dem Schluss, dass umstehende Personen einen Anstieg in passiven Beobachtungen auslösen, ebenso die Initiierung von motorischen Funktionen, die den Körper darauf vorbereiten sollen, eine Handlung auszuführen. Diese Studie illustriert, dass der Bystander-Effekt aus einem sehr komplexen Zusammenspiel von verschiedenen Gehirnregionen besteht, das die Entscheidung bezüglich des Handelns in dieser Situation einen neuronalen Konflikt auszulösen scheint. Auf der Verhaltensebene äußert sich die Komplexität dieser Situation in jenen Gründen, die von Latané und Darley (1970) genannt wurden.

Das Ziel dieser Sudie war es, die zugrundeliegenden Mechanismen des Bystander-Effekts weiter zu untersuchen, um eventuell die Ergebnisse von Hortensuis und de Gelder (2014) zu replizieren oder sie anzupassen. Unsere Erwartungen inkludierten die erhöhte Aktivität in jenen Hirnregionen, die mit dem empathischen Netzwerk laut Derntl et al. (2010) assoziiert sind: Teile des Limbischen Systems, des inferioren frontalen Gyrus, des rechten superioren temporalen Gyrus und des linken mittleren temporalen Gyrus. Wir nehmen auch an, dass diese Areale während der *Bystander*-Situation in ihrer Aktivität verringert werden und eine Aktivitätenverlagerung hin zu jenen verantwortlich für Aufmerksamkeit, visuelle Wahrnehmung und die Vorbereitung einer Handlung erfolgt.

Für die vorliegende Studie wurden 26 männliche, italienische Teilnehmer mit einem fMRI-Gerät gescannt, während sie 16 verschiedene Szenarien auf einem Monitor lasen. Die Szenarien bestanden aus vier verschiedenen Situationen und ergaben daher ein 2x2 Studiendesign mit den Faktoren *context* (single vs. bystander) und *target* (person vs. object). Dem Studiendesign wurde dann eine behaviorale Datenanalyse sowie einer ersten und zweiten Ebenenanalyse unterzogen, die die Resultate eines Haupteffekts in der *object vs. person* ($F(1,23) = 18.05$, $p < 0.05$, $p\eta2 = 0.440$) Bedingung und eine signifikante Interaktion (*bystander vs. single vs. person vs. object* ($F(1,23) = 4.85$, $p < 0.05$, $p\eta2 = 0.174$)) hervorbrachten.

Es wurde auch eine whole-brain-Analyse durchgeführt ($p < 0.05$), welche unsere auf der Literatur basierenden Hypothesen zum Großteil bestätigten. In empathische Prozesse involvierte Gehirnregionen wie der Frontallappen, die Insula und das Cingulum, waren während der *person vs. object* Situation in ihrer Aktivität erhöht. In der *bystander vs. single* Bedingung zeigte der Okzipitallappen und der Precuneus ebenfalls erhöhte Aktivität, während Empathie-assoziierte neuronale Bereiche eine verminderte Involviertheit zeigten. Diese Ergebnisse sind Indikatoren für den klassischen Bystander-Effekt auf neuronaler Basis. Zusätzlich zeigte sich durch die erhöhte Beteiligung des Cerebellums und des supplementär-motorischen Areals, dass das Gehirn in der *bystander* Situation für die Initiierung einer Handlung vorbereitet wird. Zeitgleich steht die erhöhte Aktivität des bereits erwähnten Okzipitallappens und des Cingulums für einen Anstieg in der visuellen Wahrnehmung und Aufmerksamkeit.

Die Ergebnisse müssen mit äußerster Vorsicht behandelt werden, da die Stichprobe klein ist, weibliche Studienteilnehmer von der Teilnahme exkludiert wurden und aufgrund der Komplexität des Bystander-Effekts auf behavioraler und neuronaler Ebene Behutsamkeit bezüglich einer Interpretation geboten ist. Trotzdem haben uns die vorliegenden Daten erlaubt, weitere wichtige Einblicke in die noch zum Teil unklaren neuronalen Mechanismen dieses Phänomens zu sammeln.

Den Vorsitz der Studie hatte Giorgia Silani, PhD, von der Universität Wien und Andrea Caranghi, PhD, von der Universität in Triest in Kooperation mit der italienischen SISSA Abteilung. Die Teilnehmer wurden in Turin zu Beginn des Jahres 2014 rekrutiert und gescannt.

ABSTRACT

In December 2014 a 58-year-old man was found dead in an elevator of the Viennese public metro system after struggling from heart failure for five hours. One of 12 surveillance monitors at the metro station captured his long lasting agony, presumably including the employees who were in charge of surveillance on that night. Several people used the elevator while the homeless was lying at their feet in pain. Help finally came when a cleaning worker called the ambulance. But it was too late. The man died on the way to the hospital (Möseneder, 2015).

The bystander effect is the well-established psychological phenomenon, which explains that individuals are less likely to help a victim, the more bystanders are present. In short, the more bystanders, the less likely the victim will be helped. Latané and Darley (1970) explain the effect from three angles: by a diffusion of responsibility on other observing people; by evaluation apprehension due to a person´s fear of being judged by others when interfering; and by pluralistic ignorance, stating that the ambiguous situation suppress the motivation to help collectively.

Whereas hundreds of studies exist from a socio-psychological point of view on the bystander effect (for a summary see Fischer et al., 2011), very few investigations have been made yet about the brain´s implication in this specific setting.

A recent study of Hortensius and de Gelder in 2014 was the first investigation about the brain´s role in a classic bystander situation including up to four bystanders and a victim in need. By scanning their participants with fMRI-device, the authors were able to examine underlying neural mechanisms that influence helping behavior. When no bystanders – or only a few present in an emergency situation- the left pre- and postcentral gyrus and the medial frontal gyrus become significantly active. These brain regions are involved in the empathy-related processes. In contrast, an increase in the number of bystanders triggers other neural areas such as the superior occipital gyrus, the right lingual gyrus, the left cuneus and the left middle temporal gyrus. In addition, brain regions associated with an enhanced visual perception and attention, as well as preparation for action, showed increased activity. Hortensius and de Gelder (2014) concluded that bystanders trigger both an increase in passive observations, as well as an initiation of motor functions, which make the body ready for intervening. These

findings illustrate that the bystander effect consists of a very complex interplay of various active brain regions, where a decision of how to react may cause conflicting neural responses. On a behavioral level, the complexity of this situation often causes the reasons of the effect explained by Latané and Darley (1970).

The aim of our study was to investigate the underlying neural mechanisms of the bystander effect. In so doing, we would either replicate the findings of Hortensius and de Gelder (2014) or adapt them. Our predictions included a higher activation of the brain regions associated with the empathy network, namely parts of the limbic system, the inferior frontal gyrus, the right superior temporal gyrus and the left middle temporal gyrus according to Lamm and Singer (2010). We also expected to find a decrease within these areas in the bystander situation and a shift of brain activity to those associated with attention, visual perception and preparation for action.

In order to test our hypotheses, 26 male Italian participants read 16 different scenarios while getting scanned with fMRI device. The scenarios consisted of four different situations and created therefore a 2x2 subject design with the factors *context* (single vs. bystander) and *target* (person vs. object). The subject design entered a behavioral data analysis and a first- and second-level analysis, resulting in a significant main effect of *object vs. person* ($F(1,23) = 18.05$, $p < 0.05$, $p\eta^2 = 0.440$) and a significant interaction of *bystander vs. single vs. person vs. object* ($F(1,23) = 4.85$, $p < 0.05$, $p\eta^2 = 0.174$).

Also, a whole-brain analysis was conducted ($p < 0.05$), showing that our predictions based on the literature were for the most part valid. Empathy-related brain regions like the frontal lobe, the insula and the cingulum in the person vs. object condition showed increased activity. In the situation bystander vs. single, an increase in the occipital gyrus and precuneus, as well as decreases within empathy-related networks, are indicators for the classical bystander effect. Additionally, the cerebellum and supplemental motor area illustrate that the brain is triggered for preparation for action by ambivalent situations. At the same time an enhanced visual perception and attention is a consequence of increased activity in the occipital gyrus and the cingulum.

The interpretation of our findings are made with great precaution due to our small sample size, the exclusion of female participants and out of respect for the great complexity of the bystander effect on a behavioral and neural level. Yet we were able to gain further insight into the poorly understood neural mechanisms of this phenomenon.

The study was chaired by Giorgia Silani, PhD, from the University of Vienna and Andrea Caranghi, PhD, from the University of Trieste in cooperation with the Italian SISSA Unit. The participants were recruited and scanned in Turin at the beginning of 2014.

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1. INTRODUCTION

1.1. Social cognition

Social cognition is the personal mental representation of the world in which an individual is embedded. It includes beliefs about people, social groups and the relationships between them, as well as patterns of social behavior and dynamics within groups. By encoding and interpreting events and observations, an information analysis about social psychological phenomenon is provided. Knowledge about causes, courses and consequences of social events gets built up constantly. It enriches those individual mental representations with the goal to facilitate social interactions and taking actions (Brewer & Hewstone, 2004).

1.2. Empathy

Ancient Greek literature provides an example of how the root meaning of the word “empathy”. For example, Aristotle let one of his protagonists in the book *On Dream* feel intense fear by imagining his enemy triumphing over him. Back then, the Greek word *empathes* used to mean *experiencing a strong emotion* or *being affected by* (Agosta, 2010).

The concept and meaning of empathy morphed even more in 1903 by Lipps, stating that the German word “Einfühlung” means to empathize with somebody, to put yourself into the shoes of others, to feel into somebody (see Kellnar, 2012). The empathic response to a person´s expression of emotion is thereby “*innate, involuntary and isomorphic”* (see Hoffmann, 2000, p. 37).

From an evolutionary-biological perspective (e.g. Wilson, 1978), empathy might improve the genetic fitness because it provides the basis for survival, reproduction and the concern about the offspring. Being empathic was crucial for the development of human kind.

Almost 100 years after Lipps´ attempt to establish the term *empathy*, Hoffmann (2000) added more details to the psychological construct, which he defines not only in terms of the outcome (affect match), but in terms of the underlying process between the observer and the person being observed:

“The key requirement of an empathic response according to my definition is the involvement of psychological processes that make a person have feelings that are more congruent with another´s situation than with his own situation.” (p. 30)

Hoffman underlines that having empathy for someone arouses the observer physically which makes it more likely to perform some sort of prosocial moral action toward the person being observed (see for example the study of Penner et al., 1995). Empathy can therefore precede helping behavior. Also, observers help quicker if the victim shows more pain and when their own empathic distress is high rather than low (as cited in Hoffman, 2000, see p. 31&32).
Empathy is furthermore the basis for altruism, moral sense, ethical concerns and necessary for building up and maintaining social relationships.

Empathy not only refers to a feeling one can have for people, animals and objects in the environment. It is also a cognitive process of perspective taking (Ickes, 1993). Decety und Lamm (2006) combine affective and cognitive aspects and see empathy as a multidimensional process which includes bottom-up as well as top-down mechanisms: There are unconscious and automatic connections between personal emotional experiences and the perception of the emotional state of another person on the one hand, and conscious, cognitive regulative processes underlying an executive control of the empathic reaction on the other. Thus, according to the authors (2004), the core components of empathy are recognizing emotions of the self and others through facial expressions; behavior or diction; then affectively sympathizing with someone as well as taking the emotional perspective of somebody else. This process distinguishes human beings from animals to some extend since we are conscious about the difference between our own feelings and those of others (Decety and Lamm, 2004).

Even though empathy is to some extent genetically determined (Walter, 2012), the accuracy of emotional perspective-taking seems to be something that can be improved by training. Marangoni and colleagues (1995) found evidence within their study that gradual improvement of empathy is possible in a simple and quick way. Their participants repeatedly rated feelings and thoughts of others by looking at people´s facial expressions shown in a video. Then, they were given feedback on the actual emotional state of the stimuli. This resulted in a statistically significant improvement of the accuracy of assessing other´s true feelings and thoughts. According to the researchers, this adaption of empathic perception was shown to have a long-lasting impact on the participants. These findings are especially relevant for the therapy of psychological disorders characterized by an impairment of cognitive empathy, such as autism (Demurie et al., 2011), schizophrenia (Derntl et al., 2009) and affective disorders (e.g. Seidl et al., 2012).

The flexibility of empathy is also expressed by looking at the consequences of affective and cognitive empathy. Taking the perspective of emotionally feeling for others might lead to altruistic motivated behavior like a willingness to help (Batson, 1987). Many researchers question whether it is necessary to differentiate between affective and cognitive empathy since both processes might overlap within a setting like the bystander situation, for example.

1.3. Helping behavior

During the 1980s, many researchers believed that acting prosocial toward someone is never a fully altruistic behavior. Wispé (1987) called it the *hedonistic paradox*, stating that even the most altruistic act is in the end always for the benefit of the actor. Daniel Batson (1981), a pioneer in investigating empathic processes, reversed this perspective by claiming that the personal gain (e.g. personal satisfaction, relief) of helping someone else is an unintended by-product rather than the goal of the helping behavior. Helping somebody can be a genuine altruistic act with the intention to reduce the other´s personal distress. An egoistic motivation on the other hand implies the goal of reducing one´s own personal distress caused by seeing somebody else in need. Removing the source of the stress may be accomplished by either helping the person in need or by escaping the situation altogether either physically or psychologically. The easier it is to leave a bystander situation, the more likely it is to avoid observing the victim´s suffering. This can reduce one´s own stressful feelings. Even if the helping behavior combines both altruistic and egoistic motives, the end-state goal, not the behavior, reveals an act as altruistic. By looking at the results of more than 30 experiments (as cited in Kellnar, 2012), Batson concluded to support the empathy-altruism hypothesis, claiming that empathic concern (includes feelings of sympathy, compassion, tenderness towards others) produces altruistic motivation or initiates helping behavior.

1.4. The bystander effect

A 28-year old woman named Kitty Genovese was raped and murdered in 1964 in New York City while more than 30 of her neighbors witnessed the crime without intervening. This case was probably the starting point of investigating the phenomenon of people not carrying out helping behavior, which increases if passive bystanders are present. This phenomenon was later named “bystander effect” and has been established through various experiments and field situations (e.g. Shaffer et al., 1975). It was shown that it occurs for both sexes of participants and victims (e.g. Latané & Dabbs, 1975), across nearly all age groups except for very young children (Staub, 1970) and quantitatively more in cities than in rural areas (e.g. Merrens, 1973). The likelihood of performing helping behavior increases if the bystanders are friends (Latané & Rodin, 1969) and decreases if there are limited communication possibilities (Latané & Nida 1981) in the situation. People also tend to help somebody they perceive to be similar to themselves because it facilitates identification with the observed person as well as empathy (e.g. Hornstein, 1976). The bystander effect usually vanishes if the situation is very dangerous (e.g., Fischer et al., 2006), which will be discussed further below. Varying results occur for example depending on the competence of bystanders. For instance, sometimes bystanders who are perceived as highly competent reduce the bystander effect (e.g. Horrowitz, 1971) and sometimes it is the other way around (e.g. Darley & Latané, 1968).

There are many theories why the bystander effect occurs. The most cited (Fischer, 2011) are those of Latané and Darley (1970), claiming that diffusion of responsibility, evaluation apprehension and pluralistic ignorance are the most influential reasons for decreased helping behavior in a bystander situation. The first describes the tendency to put one´s own sense of responsibility on passive bystanders, believing that somebody else will feel responsible for performing help. Evaluation apprehension occurs if a bystander is afraid of being judged by others because of showing inadequate behavior or making mistakes in public. The person therefore avoids taking action when he or she feels observed by others. The last mentioned reason for interfering helping behavior according to Latané and Darley (1970) is to assume that other people have different values or beliefs than oneself because they don´t show their intended behavior tendencies (like acting prosocial towards a victim) in an ambiguous situation. This misconception leads to a different personal helping behavior, even though it is acting against one´s own beliefs.

The observation and response to the distress of another individual are very basic evolutionary mechanisms that humans have in common with animals (Preston, 2013). They might lead to spontaneous, implicit action taking. At the same time, a bystander situation is cognitively very demanding and operates on a high level of top-down processes. Several steps are necessary for intervening a situation and performing help, which Latané and Darley (1970) summarized in a very basic five-step psychological process model:

1. The bystander notices there is a critical situation.
2. Construe the situation as an emergency.
3. Develop the feeling of personal responsibility.
4. Believes he or she has the skills necessary to resolve the situation.
5. Makes a conscious decision to help.

The meta-analysis of Fischer and colleagues (2011) with over 7,700 participants from studies from the 1960s to 2010 shows that additional bystanders can also have a positive effect on the helping behavior outcome despite an increased risk of negative consequences for the helper. The authors provide potential explanations to this opposite effect:

First, arousal and the costs of no intervention might inhibit the bystander effect especially in a particularly dangerous situation (e.g. perpetrator tries to rape victim) even though there is an increased risk of negative consequences if the observer decides to intervene. Fischer and colleagues (2006) believe that dangerous situations produce higher arousal for the bystander and are recognized more clearly than an ambiguous situation, which can cause confusion about how to react. These principles of the so called cost-reward model (see e.g. Dovidio et al., 1991) occur the strongest

if there is both a high level of danger for the victim and for the bystander in case of intervention. A dicey situation might cause physical arousal which can be reduced by performing help to the victim.
Secondly, bystanders are potential sources of physical support in the face of fear. In a situation with a perpetrator and a victim, it is possible that the perpetrator will also attack the helper if someone tries to intervene. Additional bystanders may cooperate and try to defeat the attacker together, which would reduce the diffusion of responsibility. This effect occurs mostly if bystanders are considered competent (e.g. Cramer et al., 1988; where high competent participants were nurses, low competent participants were students).
Lastly, the bystander effect can be attenuated by expecting the emergency to be resolved by cooperating and coordinating between bystanders. This is facilitated by making rational choices and following an informational approach.

These relatively recent findings of Fischer et al. in 2011 show that a bystander can provide social, physical and psychological support, especially in dangerous situations, instead of reducing the probability of the victim to be helped. The investigators of the meta-analysis conclude that the bystander effect may have declined over the years because of growing social psychological knowledge within the public. Beaman and colleagues (1978) for example found that implicit knowledge about the mechanisms of the bystander effect given in a lecture has long-lasting impacts on prosocial actions within bystander situations for the students who attended the lecture compared to those who did not. The reasons for the declining remain unknown and still it is possible that a regression effect flattened the bystander effect (Fischer et al., 2011). Still, Fischer and colleagues (2011) found also significant evidence that the bystander effect becomes stronger when more bystanders are present.

1.5. Neurological basis

Sociopsychological constructs like social cognition, empathy, helping behavior and the bystander effect have been examined within various behavioral analysis settings for decades. They are all proven to be very well-established psychological concepts, essentially for the co-existence of people and the understanding of emotions and behavior. However, it is surprising that the neural correlation of it has not been much examined.

A breakthrough came in the research of neural activation in empathy when monkeys' brains were studied. Using direct recording in the brain, it was discovered that mirror neurons fire in the monkey´s premotor cortex when the animal performs hand movements as well as when it observes another monkey or human doing the same hand movements (e.g. Ferrari et al., 2003). The same findings were shown in equivalent studies of human´s brains (e.g. Kohler et. al, 2002).

What seems to be scientifically established is the increased activation of the dorsal anterior cingulate cortex (dACC) in empathic responses. This region is active during the experience of physical pain as well as during the observation of someone else being in pain (e.g. Morrison et al., 2007) which supports the mirroring process theory.

One interesting Functional Magnetic Resonance Imaging (fMRI) empathy research study has been held by Rameson and his colleagues in 2011, which examined the empathic responses of 32 participants under several conditions. Since most of the previous studies were performed within a setting of participants in pain, they wanted to examine whether dACC and other connected brain regions are also involved in empathy for sadness. The authors figured that sad, rather than painful stimuli, are more common in an everyday life event. They also used daily experience sampling techniques in order to make predictions about prosocial behavior in everyday life and not just in hypothetic situations.
It turned out that the (medial) prefrontal cortex (MPFC) and the ACC in some form were active throughout all conditions. Namely, the dACC, the subACC and ventral striatum were highly engaged in situations with greater experienced empathy. Helping behavior toward a friend was correlated to MPFC and dACC, as well as the nucleus caudate and the precuneus. Helping a stranger or acquaintance is neurologically expressed slightly differently by a higher activation in MPFC and subACC. A high score on self-reported experienced empathy seems to increase the likelihood of an empathic response and the initiation of consequent behavior in general.

The important role of the medial prefrontal cortex (and increased activity in the anterior insula) in predicting prosocial behavior has also been shown by another study (Masten et al., 2011) where social pain was examined.

Multiple studies revealed (e.g. Phelps, 2006) that the amygdala plays a major role in evaluating emotional stimuli. A meta-analysis from Decety, Lamm and Singer showed in 2011, that the right anterior insula is responsible for regulating the affective part of empathy (Wicker et al., 2003). Including nine studies and 168 participants, they also showed that the hemispheric asymmetry of empathy-related brain activation is probably an artifact of thresholded statistical images rather than an actual matter of fact.

Other parts of the limbic system like the Hippocampus are also involved in emotional perspective-taking (Schnell et al. 2011).

Beside the limbic system, the inferior frontal gyrus, the right superior temporal gyrus and the left middle temporal gyrus are part of the neuronal network of empathy according to Derntl et al. (2010). More specifically, the inferior frontal and superior medial frontal gyrus are active if the initial step of evaluating social cues is carried out. The middle temporal gyrus as well as the cingular gyrus are active if knowledge about personal emotional experiences and the well-being of others and the self are required. This neural network empowers the attribution between the emotional status of the self and others while putting it into the context of past empathic experiences.

Another meta-analysis (Fan et al. 2011), including more than 40 studies, fall in line with the research findings of Rameson et al. (2011), claiming that the left dorsoanterior midcingular cortex is the neuronal basis of the cognitive aspect of empathy, apart from the emotion that were shown to the participants. Also the supplemental motor area and the bilateral anterior insula affect cognitive empathic responses.

The inferior frontal lobes seem to be involved in cognitive empathic responses as well (Walter, 2012). Ruby and Decety (2004) assume that the activation of the frontal lobes is important for the maintenance of distinction between personal perspective and the perspective of others since an activation in that area manages executive control functions. They also claim that the right inferior parietal lobe tend to be involved in empathy cognition, as well as the temporal lobes (for anterior see Schnell et al., 2011; for medial see Shamay-Tsoory, 2011).

The study of Hein et al. (2010) revealed some important aspects on the neuronal network of helping behavior. The authors took a closer look at the influence of the membership to a perceived in-group vs. out-group in a bystander situation and how it impacts the probability of helping behavior toward those members. Earlier studies (e.g. Levine et al., 2005) deliver evidence that it is more likely to help an in-group member in need than a member of an outer group. De Dreu et al. (2010) refer to this behavior tendency as “parochial altruism”, stating that in-group members are perceived as more positive than those outside the group. This perception leads to a higher identification with the person and an increased empathic concern when the in-group member is in need, which increases the likelihood to help (see for example Batson et al., 2007). It also works the other way around: The worse a member of an out-group is evaluated, the less likely the group will perform helping behavior toward that person. An example of this was given in the article mentioned in the *Abstract*, where the man who died of heart failure was and looked like a homeless person. The lack of identification to the victim due to his social status and look most likely added to the suppressed helping motivation by the bystanders. As a result, their failure to lend assistance contributed to his death. There is even reason to believe that witnessing a member of an out-group suffering results in pleasure for the observant (Lanzetta & Englis, 1989).

As mentioned, Hein and colleagues (2010) investigated the underlying neuronal mechanisms of perceiving somebody as an in- or out-group member and its consequences for the motivation to help. As a result, they found two main contradictory motivation systems active within this process. Whenever participants showed empathy-related feelings for an in-group member, the left anterior insula (AI) was active. On the other hand, the right nucleus accumbens (NAcc) showed significantly increased activation when observing an out-group member in pain.

A study from Schultz (2002) suggests in addition, that witnessing how an unpopular out-group member receives pain activates even reward-related brain regions. Similar findings were shown for example in the study of Cheng and colleagues in 2007. Surprisingly, these activations were not consistent within every evaluation condition. If an out-group member was perceived as positive, the area of the AI was activated instead of NAcc, leading to helping behavior despite the person´s membership to the out-group. This means that the bias of preferred helping behavior toward a member of an in-group can be reduced by, for example, adding more information about the person in need (Hein et al., 2010). Otherwise it seems that basing a decision of whether to help a victim or not on their belonging to a certain group leads to omitting helping behavior.

Yet, within a classic bystander situation including a person in need and bystanders, there is limited information about the bystanders or the victim. The decision whether to help the person in need or not is often based on the individual´s moral judgment. Hauser (2006) states for example, that people unconsciously evaluate a morally ambivalent situation as good or bad. Haidt (2001) on the other hand underlines the importance of intuitive emotions within moral decision settings. Today, an integrative approach is suggested: in order to make moral choices, both socio-emotional as well as cognitive processes are crucial (Moll et al., 2005). More importantly, a unique neural network seems to be responsible for specific moral decision making.

FeldmanHall and colleagues (2013) investigated the particular neural differences between easy and complex moral decisions. They found that the tempoparietal junction (TPJ) is more active if the moral situation was hard to judge. However, the ventro-medial prefrontal cortex (vmPFC) showed increased activation if the moral situation was *clear, obvious and automatic* (p. 7). These findings are negatively correlated. The increased activation of the bilateral TPJ within difficult moral settings falls in line with a decreased function in the vmPFC and orbitofrontal cortex. On the other hand, easy moral judgements require higher activation within the vmPFC and a deactivation in bilateral TPJ and the dorsolateral prefrontal cortex.

It seems that these regions play distinctive roles within the moral cognitive network. They suppress each other in order to facilitate access to the brain region responsible for solving the complexity of a certain scenario. The vmPFC therefore seems to be involved in consequences of prosocial decisions that have low costs and high benefit results. A lesion in this area leads to behavioral abnormalities within patients who have to solve a complex moral dilemma (Koenigs et al., 2007). Autistic patients show abnormal TPJ activities within Theory of Mind tasks (Baron-Cohen et al., 1999), or no TPJ activation at all (Castelli et al., 2002).

In conclusion, this means for a bystander situation that it is not only important how many elements of social cues a person must encode to finally decide to initiate helping behavior or not, but also how much effort an action would require.

Finally, Hortensius and de Gelder have delivered the most concrete findings according to the bystander effect and its underlying neural mechanisms in 2014. They scanned 17 both male and female participants while they watched videos of an emergency situation including a victim with one to four bystanders. They found the superior occipital gyrus, the right lingual gyrus, the left cuneus and the left middle temporal gyrus to be active when bystanders and a victim were present. Also, visual perception and attention related brain regions were more active the more observers were present in the scene. In contrast, when there were fewer bystanders around, the more the neural activity shifted to other brain areas. The left pre- and postcentral gyrus and the medial frontal gyrus were more active when there were less bystanders around. Furthermore, the brain regions associated with automatic action preparation became less active when less people were present. These results illustrate the behavioral outcome on a neural basis. If bystanders are present in an emergency situation, which usually omit helping behavior toward the victim, neurological responses are expressed by a reduction in the preparation for action areas, as well as in the brain regions involved in empathy-related emotion processing. At the same time, perception and attention become important, explaining why people tend to observe rather than intervene in an emergency situation. A decrease in group size often encourage people to help, expressed in the brain by an increased initiation of action-taking.

2. AIM OF THE THESIS

The purpose of this study is to investigate the neural mechanisms of the bystander effect by confronting 26 male participants with various scenarios displayed on a screen while getting scanned with an fMRI device. What we aim to measure is the hypothetical motivation of the participants to help the object or subject in the scenario and the influence on this probability when there are either no bystanders or multiple bystanders around.
In order to find out which brain regions are active within the individual conditions, a whole-brain analysis will be conducted. Additionally, the behavioral data will be analyzed.

Based on the literature, the following predictions are made:

1. There is a higher activation of the brain regions associated with the empathy network when subjects are presented to the participants compared to objects.

2. We expect the bystander effect to occur within the *bystander vs. single* condition. That means that with an increase of group size, the empathy-related brain areas are reduced in activity. Also, we predict a shift of brain activity within the brain areas associated with attention and visual perception.

3. METHODOLOGY

3.1. Participants

Approved by the Bio-Ethical Committee of the University of Turin, the study was carried out at the beginning of 2014 by an interdisciplinary research team chaired by Giorgia Silani, PhD, from the University of Vienna and Andrea Carnaghi, PhD, from the University of Trieste. Additional staff was provided from the Italian SISSA Unit (International School for Advanced Studies) and the sector of Cognitive Neuropsychology and Brain Imaging.

The sample consisted of 26 healthy Italian students with an average age of 20.9 years. Only male participants were recruited in order to avoid a bias of hypothetical prosocial behavior tendencies (see for example Ickes et al., 2000).

The data of two experimental subjects were necessary to exclude from the analysis due to technical difficulties with the fMRI device. Participants were recruited through verbal requests in lectures, courses, the library and various university departments of the University of Turin. Studying Psychology and/or Economics were exclusion criteria for participation. Economic students were not preferred because a business game was carried out from another research team before the experiment of the current study took place. The students did not receive any financial incentives for participation.

All of the subjects were right-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971) and had normal or corrected-to-normal vision. Exclusion criteria were also a history of neurological or psychiatric disorder and the current intake of medication affecting the central nervous system.

Blood-oxygen-level-dependent (BOLD) responses were measured by using Functional Magnetic Resonance Imaging (fMRI) technique via a Signa 1.5 Tesla head scanner (GE Healthcare, Milwaukee, Wisconsin), located at the CTO Hospital in Turin. One functional run was carried out by using T2*-weighted Echo-Planar Images (EPI) (TR=2.25s, TE=50ms, slice-matrix=80×80, slice gap=0.28 mm, field of view (FOV) =21). Anatomical images were measured with a resolution of 1 mm^3 (TR=7.92 ms; TE=2.4 ms; TI=910 ms; BW=195 Hz/Px; α=15°).

3.2. Structure of the study

Before getting scanned, all participants received a written informed consent about the procedure and content of the study. A soft padding around the participant´s head was applied to avoid head motions. A test run was carried out to make sure that the participant understood the task. Each fMRI session required an interscan interval of 2.25 seconds.

After the trial, a fixation cross appeared on the screen for two seconds in order to assure jittered ITI. The subjects were then asked to read 16 scenarios presented on the screen, which were adapted by Giorgia Silani, PhD. The scenarios were written by Andrea Carnaghi, PhD.

Those scenarios were divided into four different situations: OB (object and bystander), OS (object and single), PB (person and bystander) and PS (person and single). It is therefore a 2x2 subject design with the factors *context* (single vs. bystander) on the one hand and *target* (person vs. object) on the other.

An example for an OB situation is:

"You are alone at the beach in the early morning and there are 5 other people around you. You recognize that a parasol get knocked over by a gust of wind."

An example for OS:

"You are alone at the beach in the early morning. You recognize that a parasol get knocked over by a gust of wind."

An example for PB:

"You are alone at the beach in the early morning and there are 5 other people around you. You recognize that a swimmer, whom you have not noticed before, is dropped to the ground by a gust of wind. "

An example for PS:

“You are alone at the beach in the early morning. You recognize that a swimmer, whom you have not noticed before, is dropped to the ground by a gust of wind.”

Each of the scenarios required a decision about the participant´s hypothetical helping behavior. After the participant read the scenario, a space bar was pressed and brought up the question of *“What will you do”* on the screen. On a continuous line from *“I won´t do anything*” on the one hand and *“I will help”* on the other, the subjects had to position an answer by pressing a button to either their left or right side within eight seconds. It was collected how much the subject was willing to help someone in need, therefore the probability of the participant´s helping behavior. The scoring then entered a 2x2 factorial design.

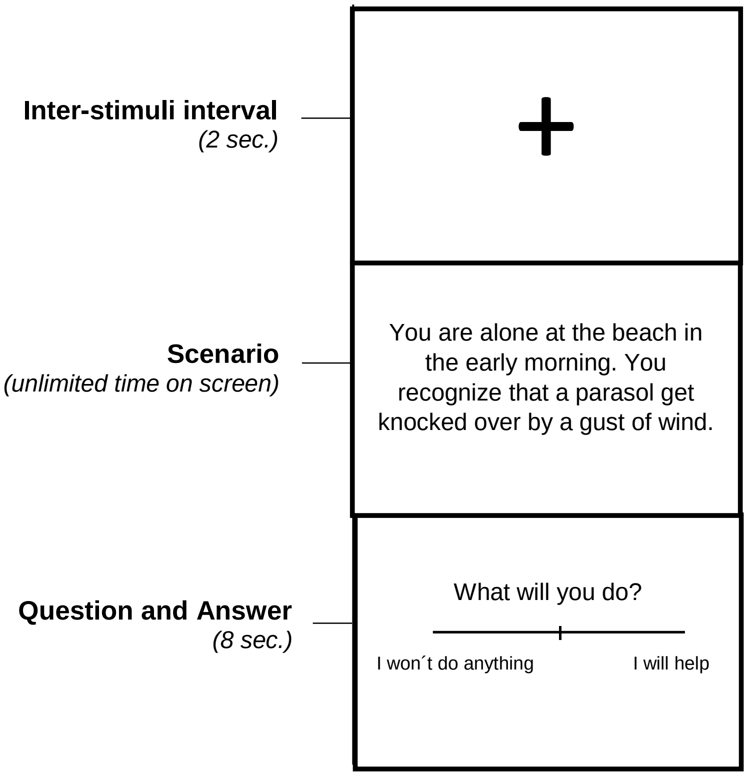

Figure 1: Example of a typical scenario presentation. On the left the category and duration is shown, on the right how the experimental stimuli is presented from the perspective of a participant.

After the scan, participants were asked general questions about the study and were then dismissed. The experiment lasted approximately 20 minutes per person.

3.3. Behavioral data analysis

A statistical analysis of behavioral data was done by the usage of SPSS 12 (IBM). In order to operate a 2x2 ANOVA, the average rating time and the average score (from -10 to +10) for each condition was calculated. A D´Agostino-Pearson test ($p > 0.005$; all tests were parametric) ensured no violations of normality assumptions for the variables of interest. No Bonferroni correction was made.

3.4. fMRI data acquisition

Data were analyzed by SPM8 (http://www.fil.ion.ucl.ac.uk/spm/software/spm8/; Wellcome Department of Imaging Neuroscience, London, UK) and Matlab (MathWorks), following the guidelines of Poldrack et al. (2008). After some preprocessing steps, a first- and second-level analysis was done.

Within this study, indirect normalization was used in order to analyze the voxel-based data. Five preprocessing steps including realignment, co-registration, segmentation, normalization and smoothing were done to assure that artifactual changes of the voxel values are removed as much as possible.
Initially, the first four scans of each participant were removed in order to avoid T1-equilibration effects. The volumes got realigned to the first volume and then to the mean realigned image with the intention of clearing out effects of the subject´s movements while getting scanned. The average of the re-sliced and motion-corrected images were then co-registered to each individual´s scan to normalize mutual information. As a last step, the scans got smoothed to enhance the probability of detecting large clusters within the brain and to optimize the quality of the images.

The first-level analysis operated with a 2x2 factorial design (*context*: single vs. bystander; *target*: object vs. person) and therefore four regressors of interest (OB, OP, PS, PB). The output of the statistical analysis of the fixed-effects design matrix was visually inspected. No collinearity between regressors was found which supports statistical power. After estimating the data, they entered the second-level analysis.

A single full-factorial design was conducted to analyze group-level random effects by generating contrasts for a second-level between-subject ANOVA. The whole-brain analyses was thresholded at $p < 0.05$ and the Family-wise Error (FEW) corrected at the level of 10 since, according to Poldrack and colleagues (2011), a sample size smaller than 20 might be too conservative.

4. RESULTS

4.1. Behavioral analysis

Table 1 illustrates the results of the descriptive statistics of the behavioral data. The effects of the factors *context* and *target*, as well as the interaction were investigated. Behaviorally, no significant bystander effect or interaction occurred. These findings get relativized by looking at the results separately. In contrast to *bystander vs. single within objects*, the condition of *bystander vs. single within person* shows a statistical significant difference. It means that if a person is present within a scenario, the behavior tendency differs from having bystanders around versus being by oneself.
No correlation was found within the behavioral analysis.

Factor	**Stimuli**	**Mean**	**SD**	**CI 95%**
Context	object	1.74	0.44	[0.83, 2.64]
	person	3.55	2.39	[3.05, 4.04]
Target	bystander	2.44	3.64	[1.69, 3.2]
	single	2.84	2.87	[2.25, 3.43]
Interaction	object vs. person (single condition)	1.75	0.53	[0.65, 2.86]
		1.72	0.51	[0.67, 2.77]
	object vs. person (bystander condition)	3.14	0.35	[2.41, 3.86]
		3.96	0.25	[3.45, 4.47]

Table 1: Descriptive statistics of the factors context and target, as well as the interaction, are shown. The table includes the Mean, Standard Deviation (SD) and 95% Confidence Interval (CI).

The 2x2 ANOVA factorial design revealed a significant main effect for the contrast *object vs. person* ($F(1,23) = 18.05$, $p < 0.05$, $p\eta 2 = 0.440$), which leads to the assumption that participants perceived objects presented in a scenario differently from subjects. Behaviorally, people in need triggered more often (M= 3.55, SD= 2.39) the intended motivation to help compared to objects (M= 1.74, SD= 0.44). This main effect is also expressed by a statistically significant interaction of *bystander vs. single vs. person vs. object* ($F(1,23) = 4.85$, $p < 0.05$, $p\eta 2 = 0.174$). Therefore, depending on the factor *target*, subjects and objects caused different behavioral response in the sense that subjects caused more often a motivation to help than objects in the person condition.

The main effect *bystander vs. single* did not, at least for the behavioral analysis, show significant results ($F(1,23) = 1.33$, $p > 0.05$, $p\eta 2 = 0.055$). This means that the classical bystander effect of reduced helping motivation with an increase in group size did not occur. A possible explanation for that is presumably the small sample size with data of only 24 valuable participants.

No significant correlations between the conditions were detected.

4.2. Whole-brain analysis

For the whole-brain analysis, the following contrasts were carried out ($p < 0.005$, FEW-corrected, $k > 10$):

Main effect: object vs. person

Contrasting object vs. person show activation in the left frontal middle gyrus, the right frontal middle orbital gyrus, in both hemispheres of the frontal inferior operculum, the left and right anterior insula, the right putamen, and the left hemispheres of the thalamus and cerebellum.

Anatomical area	**p (uncorrected)**	**Z-value**	**Number of voxels**	**MNI coordinates of local maxima**		
				x	**y**	**z**
L frontal middle gyrus	0.001	3.36	190	-42	50	12
L frontal middle gyrus	0.002	2.83	190	-38	50	28
L frontal middle gyrus	0.002	2.84	10	-22	28	36

R frontal middle orbital gyrus	0.002	2.88	47	42	52	-4
L frontal inferior operculum	0.002	2.84	77	-42	20	-10
L frontal inferior operculum	0.001	3.00	20	-60	14	26
R frontal inferior operculum	0.002	2.83	47	36	44	-4
L ant insula	0.001	3.02	77	-42	16	8
L ant insula	0.001	2.98	27	-32	168	16
R ant Insula	0.001	3.78	216	34	18	-4
R Putamen	0.001	2.74	216	28	20	4
L Thalamus	0.002	2.88	39	-14	-8	2
L Cerebellum	0.001	3.23	59	-12	-52	-50
L Cerebellum	0.001	3.15	59	-12	-60	-48

Table 2: Activation of brain regions for the main effect object vs. person

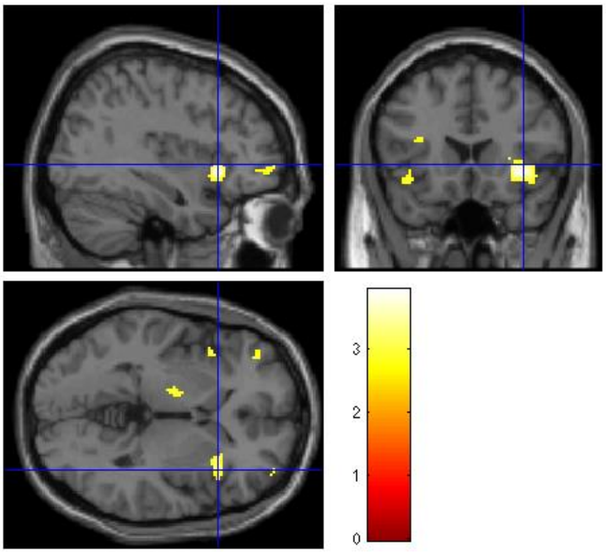

Figure 2: Exhibited brain regions showing increased activity within the object vs. person contrast.

Main effect: person vs. object

An increased activation of the left and right frontal orbital gyrus, the right anterior orbital gyrus, both left and right middle cingulum, the left posterior cingulum, the rolandic operculum and the right posterior insula were shown. Similar as in the first main effect, the frontal cortex, the insula (Shamay-Tsoory et al., 2008) the orbital gyrus (Hornak et al., 2003) and the cingulate cortex (Phan et al., 2002) influence the emotional network of empathy in different ways.

Anatomical area	**p (uncorrected)**	**Z-value**	**Number of voxels**	**MNI coordinates of local maxima**		
				x	**y**	**z**
L frontal medial orbital gyrus	0.001	3.75	154	-2	54	-6
R frontal medial orbital gyrus	0.001	3.04	154	10	48	-6
R anterior cingulum	0.001	3.11	53	12	48	14
L middle cingulum	0.001	3.17	21	-12	-16	42
R middle cingulum	0.003	2.73	13	6	-18	32
L posterior cingulum	0.001	3.03	88	0	-44	32
L posterior cingulum	0.003	2.77	88	-12	-44	28
R rolandic operculum	0.003	2.71	15	-44	-12	22
R posterior insula	0.001	3.26	41	34	-10	12

Table 3: Activation of brain regions for the main effect person vs. object

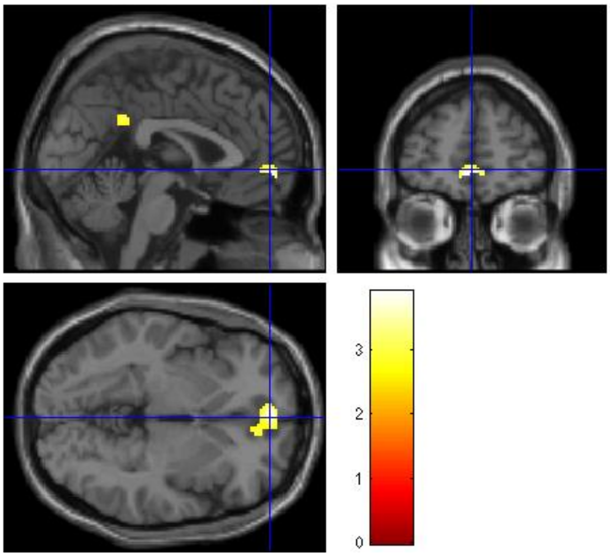

Figure 3: Exhibited brain regions showing increased activity within the person vs. object contrast.

Main effect: bystander vs. single

Contrasting the *bystander vs. single* condition revealed an activation of the cerebellum in both hemispheres. There was also increased activation in the left inferior occipital cortex, the left precuneus, right middle cingulum, right supplemental motor area and the right superior occipital area. The activation within the cingulum and supplemental area are associated with cognitive empathic responses (Fan et al., 2011). The cerebellum might mainly function as a supporter and coordinator of the active brain regions and motor functions (van Overwalle et al., 2014).

Anatomical area	**p (FEW-corrected)**	**Z-value**	**Number of voxels**	**MNI coordinates of local maxima**		
				x	**y**	**Z**
L Cerebellum	0.001	4.26	899	-18	-60	-40
L Cerebellum	0.001	3.47	899	-38	-54	-24
L Cerebellum	0.001	3.20	899	-28	-62	-26
R Cerebellum	0.001	4.06	331	44	-60	-28
R Cerebellum	0.001	3.64	331	34	-62	-28
L inferior occipital area	0.001	3.46	112	-40	-70	-2

R superior occipital area	0.001	2.99	165	26	-78	22
R superior occipital area	0.004	2.62	163	26	-80	12
L Precuneus	0.001	3.36	190	-4	-70	58
R middle cingulum	0.001	3.32	355	10	2	36
R supplemental motor area	0.001	3.17	355	10	2	56

Table 4: Activation of brain regions for the main effect bystander vs. single

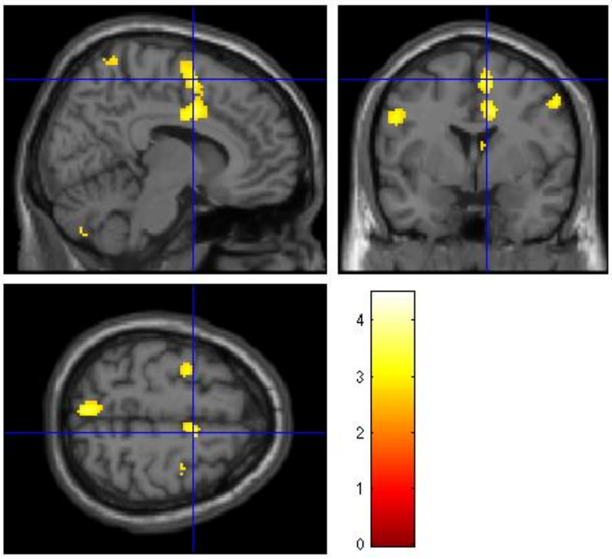

Figure 4: Exhibited brain regions showing increased activity within the bystander vs. single contrast.

Single vs. bystander

No voxels survived after putting the conditions of *single vs. bystander* into contrast.

Interaction: bystander vs. single vs. person vs. object

The interaction between *bystanders vs. single vs. person vs. object* illustrates a shift of active brain regions from mainly emotional parts of empathy to neural areas associated with attention. Overall, there are significant activations in the left middle cingulum, the left supplemental motor area, the left postcentral gyrus, the left inferior and superior parietal gyrus, as well as the right superior parietal gyrus, the left precuneus and the left superior temporal pole.

Anatomical area	p (FEW-corrected)	Z-value	Number of voxels	MNI coordinates of local maxima		
				x	y	z
L middle cingulum	0.004	2.69	103	-14	-6	50
L middle cingulum	0.001	3.32	103	-14	-6	50
L supplemental motor area	0.001	3.06	103	-16	-12	64
L postcentral gyrus	0.002	2.91	80	-42	-32	56
L postcentral gyrus	0.005	2.60	80	-32	-36	56
L postcentral gyrus	0.003	2.78	80	-40	-32	44
L inferior parietal gyrus	0.002	2.81	412	-34	-46	56
L superior parietal gyrus	0.001	3.01	412	-28	-52	58
L superior parietal gyrus	0.001	3.28	412	-18	-62	60
R superior parietal gyrus	0.002	2.82	114	16	-58	68
R superior parietal gyrus	0.001	3.16	114	16	-60	60
L Precuneus	0.001	3.17	75	-6	-70	46
L superior temporal pole	0.001	3.28	30	-30	12	-26

Table 5: Activation of brain regions for the interaction bystander vs. single vs. person vs. object

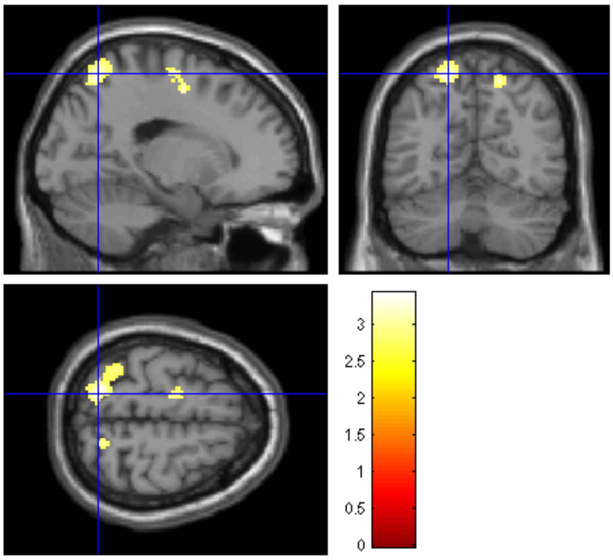

Figure 5: Exhibited brain regions showing increased activity within the interaction of bystander vs. single vs. person vs. object.

Interaction: bystander vs single vs. object vs. person

Contrasting the interaction between the bystander, single, object and person condition did not reveal as much of the activation as the interaction described above. Still, within the right calcarine and the left caudate nucleus, increased activation was shown.

Anatomical area	p (FEW-corrected)	Z-value	Number of voxels	MNI coordinates of local maxima		
				x	y	z
R Calcarine	0.001	3.20	43	32	-60	12
L Caudate nucleus	0.001	2.98	12	-20	-22	26

Table 6: Activation of brain regions for the interaction bystander vs. single vs. object vs. person

Difference: bystander vs. single within person

When looking at differences between conditions, contrasting *bystander vs. single within person* revealed statistically significant activation in the left frontal middle cortex, the right supplemental motor area, the left precentral and both sides of the postcentral gyrus. Additionally, the left inferior parietal gyrus, the superior parietal cortex, the left and right supramarginal cortex and the left hemispheres of the precuneus, thalamus and hippocampus showed increased activation as well. In sum, the contrast of *bystander vs. single within person* shows greater neural response compared to the difference within objects. It illustrates that the brains of the participants showed greater response to a subject compared to an object despite the group size.

Anatomical area	p (FEW-corrected)	Z-value	Number of voxels	MNI coordinates of local maxima		
				x	y	z
L frontal middle cortex	0.001	3.52	202	-26	24	32
R supplemental motor area	0.001	3.37	1337	10	4	56
L precentral gyrus	0.001	3.68	1337	-30	-2	60
L precentral gyrus	0.004	2.66	202	-34	10	32
L postcentral gyrus	0.001	3.10	239	-46	-20	26
R postcentral gyrus	0.001	3.63	301	32	-30	36
L inferior parietal gyrus	0.001	3.60	2103	-34	-36	40
R superior parietal cortex	0.001	3.26	490	18	-62	56
R superior parietal cortex	0.001	3.23	490	12	-56	72
L supramarginal cortex	0.001	3.43	239	-56	-20	18
R supramarginal cortex	0.001	3.34	301	30	-38	44
L Precuneus	0.001	3.56	1337	-12	-66	56
L Precuneus	0.001	3.80	2103	-6	-72	46
L Thalamus	0.002	2.84	107	-12	-20	6
L Hippocampus	0.001	3.35	107	-18	-20	-6
L Cerebellum	0.001	2.99	92	-24	-56	-36
L Cerebellum	0.001	3.28	92	-18	-62	-36

R Cerebellum (Crus)	0.001	3.28	119	42	-62	-26
L temporal inferior gyrus	0.001	3.50	33	-52	-44	-20
R cingulum middle cortex	0.001	3.41	1337	10	4	36
R Angular Cortex	0.003	2.78	301	32	-50	40

Table 7: Activation of brain regions for the difference bystander vs. single within person

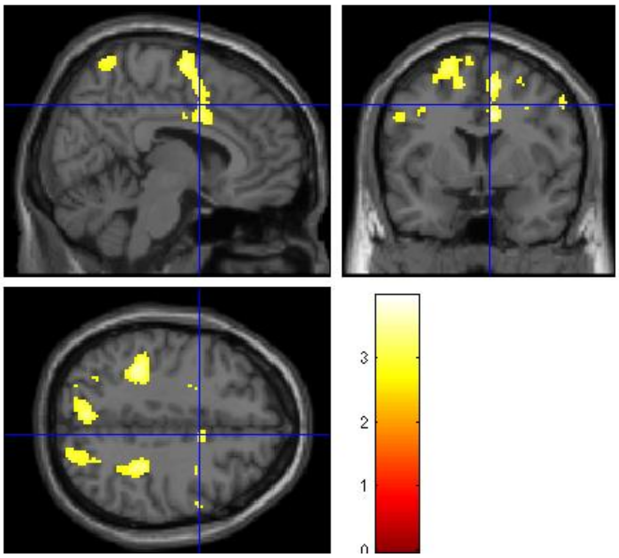

Figure 6: Exhibited brain regions showing increased activity in the bystander vs. single within person contrast.

Difference: bystander vs. single within objects

Differentiating between the *bystanders vs. single condition within objects* also showed a quite different activation pattern compared to the difference contrast above, even though the results are not as meaningful. There is increased activation in the left inferior frontal gyrus, the right supplemental motor area, the right precentral and postcentral gyrus, the middle occipital cortex, the left putamen and the right caudate nucleus. Also, both sides of the cerebellum and the right lingual cortex were active during this task.

Anatomical area	**p (FEW-corrected)**	**Z-value**	**Number of voxels**	**MNI coordinates of local maxima**		
				x	**y**	**z**
L inferior frontal gyrus	0.001	3.23	33	-48	46	6

R supplemental motor area	0.001	3.17	71	2	14	66
R precentral gyrus	0.001	3.33	21	60	16	36
R Postcentral cortex	0.001	3.12	12	-44	-6	28
L middle occipital cortex	0.001	2.98	26	-26	-80	10
L Putamen	0.001	3.06	17	-18	22	-8
R Caudate nucleus	0.002	2.84	76	10	20	-6
L Cerebellum	0.001	3.06	283	-30	-62	-44
L Cerebellum	0.001	3.31	283	-22	-50	-32
L Cerebellum	0.001	3.43	283	-14	-60	-44
R Cerebellum	0.003	2.77	58	32	-64	-30
R Cerebellum	0.004	2.66	58	40	-54	-32
R lingual cortex	0.002	2.94	11	28	-68	2
R lingual cortex	0.003	2.80	9	20	-60	0

Table 8: Activation of brain regions for the difference bystander vs. single within object

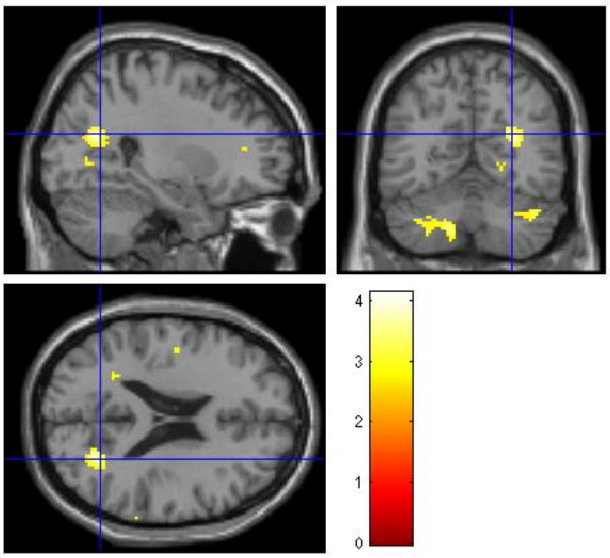

Figure 7: Exhibited brain regions showing increased activity in the bystander vs. single within object contrast.

Single vs. bystander within person and single vs. bystander within objects

No voxels survived within these conditions.

5. CONCLUSION

The main goal of the current study was to investigate the underlying neural mechanisms of the bystander effect. Even though the phenomenon of decreased helping behavior with an increase in group size yielded precious insights from a socio-psychological point of view, there is only one existing paper on this point (Hortensius and de Gelder, 2014) about how the brain responses in that setting. This study is therefore the second scientific attempt to gain further insight into the neural pattern of the bystander effect. For this purpose, 26 male Italian participants were recruited and scanned with a fMRI device while reading 16 different scenarios consisting of a variation of the two main factors *context* (object vs. person) and *target* (bystander vs. single).

The behavioral analysis showed varying results. On the one hand, the main effect of *object vs. person* was statistically significant ($F(1,23) = 18.05$, $p < 0.05$, $p\eta 2 = 0.440$), stating that participants paid more attention to subjects within the scenarios (M= 3.55, SD= 2.39) than to objects (M= 1.74, SD= 0.44).
On the other hand, the bystander effect in the *bystander vs. single* condition was too weak to be seen as a statistically significant behavioral pattern ($F(1,23) = 1.33$, $p > 0.05$, $p\eta 2 = 0.055$). This is probably explained by the small sample size. Still, the bystander effect was still expressed by a distinct neural pattern, which replicates to some extent the findings of Hortensius and de Gelder (2014).

The most important findings of the whole-brain analysis are as followed:

The contrast *object vs. person* shows significant statistical findings ($F(1,23) = 18.05$, $p < 0.05$, $p\eta 2 = 0.440$) with brain regions most active in the left frontal middle gyrus. As mentioned in the *Introduction*, Rameson et al. (2011) for example associate the prefrontal cortex with emotionally empathizing with a victim. In the current study, the increased activities in the middle, orbital and inferior frontal gyrus very likely do not indicate that participants felt emotionally empathic for an object in the scenarios. The frontal lobe is associated with numerous complex processes in the brain despite its involvement with emotional empathy. Ward (2015) for example divides the key tasks of the frontal lobe into executive functions, movement and action and working memory.

Furthermore, the (pre-) frontal cortex is strongly connected to sensory systems and supports dealing with visual, somatosensory and auditory information. The medial and orbital prefrontal cortex are also involved in emotional processing and long-term memory. The increased activity of the frontal brain area might therefore be explained by the fact that participants had to deal with visual stimuli. Also, the involvement of the frontal lobes presumably shows that the presented objects in the scenarios were not just observed, the participants' bodies may have been prepared for some action-taking by the brain. It shows that the activation for perception and action overlap.

The insula has also been shown to be involved in subjective emotional experience and emotional empathy (Shamay-Tsoory et al., 2008). Hein et al. (2010) measured increased activity of the left anterior insula, which is active in this condition, whenever participants reported empathy-related feelings for an in-group member or a positively evaluated out-group member.

Fan et al. (2011) on the other hand proved through their meta-analysis mentioned in the *Introduction*, that the bilateral anterior insula affects cognitive empathic responses as well. Also important for the cognitive understanding of the mental states of others is the ventro-medial prefrontal gyrus (Shamay-Tsoory et al., 2008), which has been shown to be active as well in the *object vs. person* condition. This area and the insula, despite working separately, overlap to some extend in empathic responses.

These and other major findings according to the insula show clearly that this region plays an important role within empathic processes and responses and as a consequence, for helping behavior motivation. Yet these conclusion are made with great caution based on current study. The anterior insula has also been found to be active when participants had to pay increased attention to time perception (Craig, 2008). During this study, subjects were embedded within a time-limited answering setting. Also, the anterior insula was found to be especially active when participants had to pay attention to pain, temperature, heart rate and arousal (as cited in Zaki and colleagues, 2012). Within their paper, Zaki et al. (2012) list numerous examples proving that the anterior insula is highly involved in experiencing and monitoring emotions and bodily states. Subjects of the current study were asked to weigh their motivation to help, which asks for a reflection of emotions. Furthermore, the decision of what to do might have led to an increased heart rate within the participants in order to initiate preparation for action. As a result, this might have led to an increased activation of the anterior insula.

Both hemispheres of the frontal inferior operculum also showed increased activity within the *object vs. person* contrast. This area was found to be responsible for understanding the syntax of a sentence and was especially active when syntactically violated sentences were present (Friederici, 2003). In the current study, the left frontal operculum in the inferior frontal lobe was active while reading, which indicates that sentences were encoded syntax.
The putamen, which has been found to be active as well within this contrast, might also play a role in syntactic processing (Friederici, 2003). The putamen, along with other basal ganglia structures, therefore seems to play an important role in controlling syntactic processes during language comprehension. Also, basal ganglia are responsible for the control of voluntary movement (Bear et al., 2007), which is another indicator for the preparation-for-action in this condition.

The activation of the (left side of the) thalamus is likely derived from its crucial role in regulating conscious states, attention and cognition (Jones, 2003). Patients with injuries in the left thalamus show deficits in language, verbal intellect and verbal memory (Taber et al., 2004). Also, the thalamus has been proven to function as a gateway for multiple sensory stimuli on their way to cortexes where stimuli are further processed. In this study, the thalamus might have served for the visual stimuli to enter the primary visual cortex (Bear et al., 2007).

The cerebellum is also involved in modulating conscious attention, which Allen and Courchesne (2003) for example proved when studying with autistic patients. The activity of the cerebellum was very limited when participants only saw visual stimuli without selectively responding to them. The activity of the cerebellum in the current study might simply reveal that the participants were asked to read the scenarios and respond to the stimuli. Since the cerebellum is mainly associated with motor regulation (see for example Bear and colleagues, 2007), the increased activity of this brain area is probably also due to a preparation of action term, caused by answering the scenarios.

A recently published study from Llinas and Negrello in 2015 extends the task spectrum of the yet poorly investigated mechanisms of cerebellar activity. Beside the cerebellum´s multiple effects in executive functions, spatial cognition and verbal working memory (as cited in Llinas and Negrello, 2015), they found that cerebellar lesions lead to more than impaired motor functions. The authors state that the cerebellum is importantly involved within cognition.

All of these findings suggest that participants in the contrast *object vs. person* experienced significantly relevant mirroring processes of the situation in the emergency situation. The enhanced visual and perceptual attention indicated that the participants were willing to read and respond to the scenarios. Since the frontal lobes and the anterior insula show great activity, participants might have been indecisive about intervening or not in this setting. They might have felt empathic concern, empathic recognition and personal distress, followed by an increased heart rate, while reading and answering the scenarios. The participants probably weighed pros and cons about their motivation to help. When an object asked for attention the indecisiveness of intervening is also expressed by a longer response time.

The contrast *person vs. object* shows that the observation of an object compared to a person is expressed neurologically in a distinct different way. Yet, as in the contrast above, both hemispheres of the (medial orbital) frontal cortex were active. As already mentioned in the *Introduction* part, Rameson et al. found in 2011 that an increased activation of the (pre-) frontal cortex was found when helping behavior towards a friend or stranger was shown. This activity is caused by mirror neurons firing when observing someone in need, as well as experiencing pain personally (see e.g. Mikulincer & Shaver, 2010). The level of empathy you feel for the observed person moderates this effect (Niedenthal, 2012).

In addition to the findings of Rameson et al. in 2011, lesions of the medial orbital frontal cortex have been shown to reduce empathy, causing empathic problems in patients (e.g. Shamay-Tsoory, 2003).

Shamay-Tsoory et al. (2008) attribute specific influence of the frontal gyrus to different sorts of empathy. Differing between emotional empathy (“I feel what you feel”) and cognitive empathy (“I understand what you feel”), they see the inferior frontal gyrus (IFG) intervening with the emotional type of empathy. This assumption has also been proofed by Schulte-Rüther and colleagues in 2007. The main tasks of emotionally empathizing in this brain area are especially emotional contagion and emotion recognition (Shamay-Tsoory, 2008). Those results were conducted by investigating with patients of IFG lesions. The authors conclude that empathizing emotionally takes place chronologically before empathizing cognitively because mirror neurons fire as soon as observing someone else´s physical and emotional state (Nummenmaa et al., 2008).

Another indicator for the importance of the medial prefrontal cortex, along with the temporal-parietal junction, is its association to facilitate perspective-taking, despite the information that the brain is dealing with (Hynes et al., 2006). Still there is more reason to believe that the orbitofrontal lobe is more involved in taking an emotional perspective, rather than a cognitive. Lesions in this area lead to an impaired ability of emotion-recognizing, for positive as well as for negative emotions (Hornak et al., 2003).

Both the medial prefrontal and anterior cingulate gyri are active in this contrast and have been shown to support general emotional processes (according to the meta-analysis of Phan et al., 2002). This indicates that the imagination of the victim-in-need-situation in the scenarios, even though hypothetically presented, might have evoked some sort of emotions, most likely empathy-related emotions. The increased activation of the orbital frontal lobe shows that emotion-inducing stimuli might have been evaluated and explicitly processed (e.g. Rolls, 2004) by the participants.

Hynes and colleagues (2006) speculated that an orbitofrontal activation either result from the stories that have been presented to the participants, which increased emotions in the participants themselves, or by intuiting the subject´s feelings in the scenario.

As already mentioned, increased activity within both hemispheres of the cingulum has been found, mainly in the left posterior cingulum. the increased activity in both the frontal and the cingulate cortex indicate that in the *person vs. object* contrast, empathy and a hypothetical enhanced motivation behavior occurred when witnessing a subject in need.

We also found the right posterior insula active in this condition. This brain area has been shown to be involved in empathic responses in multiple ways (see for example Bear and colleagues, 2007). Fitting to the findings in the presented study, the co-activation of the (anterior) insula and the anterior cingulate cortex (ACC) occur in emotion and decision making tasks (Craig, 2009). More specifically, the ACC deals with the homeostatic and emotional information from the insula and turns it into behavior while controlling autonomic responses.

As within the first contrast, the *person vs. object* condition shows once again, that the perception of a certain emotion-evoking scenario and preparation for action occur simultaneously. Comparing those contrasts also show that distinctively different brain regions are active when participants are confronted with an object in the scenario compared to a subject especially in empathy-involved brain areas.

Even though the behavioral analysis did not show a significant outcome for the bystander effect ($F(1,23) = 1.33$, $p > 0.05$, $p\eta 2 = 0.055$), the analysis of the fMRI scans does.

Contrasting the *bystander vs. single* condition revealed above all an activation within the cerebellum. According to the meta-study of van Overwalle and colleagues (2014), including more than 350 fMRI studies from over 12 years (2000 until 2012), the cerebellum does not hold a particular function within the brain. Instead it builds a bridge across other brain areas, supporting them to perform their processes. The authors believe that the activation of the cerebellum increases, the more complex a motor, cognitive or emotional task becomes. Presumably, this shows that the decision of whether to help or not in the presence of bystanders is found to be rather complex.

A meta-analysis of Stoodley and Schmahmann in 2009 divides the functions of the cerebellum into five main areas of operation: First, the cerebellum is linked to motor regulation. This goal is compared to similar actions undertaken in the past. The supplemental motor area has been found to be active in this condition too, which might give an additional hint that a hypothetical decision of what to do within the scenario signals the brain to get ready for action taking. The cerebellum probably facilitates the processing of the supplemental motor area.

Secondly, the cerebellum might play a role within planning and directing goal-oriented behavior and decision making. A third function of the cerebellum has been associated with the working memory and supporting cognitive skills in complex situations. Besides facilitating the understanding of the semantic language, Stoodley and Schmahmann (2009) also find the cerebellum to be involved in the understanding of other´s emotions and spatial navigation.

The right occipital area has been found to be especially active when responding to faces (see e.g. Haxby et al., 2000). This area is presumably active because the participants imagined the bystanders having faces.

In addition, the activation of the precuneus, in combination with the superior occipital area (and parietal cortices, which were not active in the current study), are involved in visual-spatial information processing according to e.g. Leichnetz (2001) and mental imagery in general (Zhang & Li, 2012). This might allow us to conclude that the bystander situation, although just presented theoretically, was experienced rather vividly.

In sum, the findings of the current study show similarities to the recent study dealing with the bystander effect and its neural mechanisms of Hortensius and de Gelder (2014). They found the superior occipital gyrus, the right lingual gyrus, the left cuneus and the left middle temporal gyrus active when participants were confronted with an increased group size in an emergency situation. Their investigation show that the amount of bystanders in such a situation already influence the brain activity that initiates preparation for action. In contrast, when less bystanders were around, they found increased activity in those brain areas responsible for automatic action preparation, namely within the left pre- and postcentral gyri as well as in the left medial frontal gyrus. Interestingly, instead of action preparation, an increase in bystanders triggers brain areas associated with visual perception and attention. These findings clearly prove the bystander effect on a neural basis, saying that the group size negatively influence the motivation to help and leads the participants to passively observe the scenario.

Overall, the *bystander vs. single* condition indicates, due to the increased cerebellar activity, that the participants probably evaluated the scenarios and the decision to help or not as very complex. The cingulum, often proven to play an important role within complex problem solving (see for example Bear and colleagues, 2007), shows increased activity with an increase in group size, as well as the brain network associated with preparation for action taking. These results illustrate that the

participants sometimes might have quarreled with their decisions when bystanders were present, unsure whether to intervene or not.
It is questionable why emotion-related brain areas as the frontal cortex and the insula are found to be more active within the object condition compared to the subject condition.

The interaction of *bystander vs. single vs. person vs. object* is statistically significant ($F(1,23) = 4.85$, $p < 0.05$, $p\eta 2 = 0.174$) and confirms the findings described above. Only the parietal regions, namely the left inferior and both hemispheres of the superior gyrus, are active in addition. According to Shamay-Tsoory et al. (2008), the (inferior) parietal lobe is important for emotion recognition and emotional contagion as well.
Moreover, the parietal regions play a crucial role for attention. In the current study, the superior parietal regions are mainly active. In combination with the precuneus, there is evidence to believe (Behrmann et al., 2004) that the participants dealt with attentional top-down processes and goal-oriented cognitions. In respect of the bystander effect it is possible that within the interaction condition, the focus of attention shifts from the target to help somebody to the bystanders.

In summation, the current findings mostly substantiate our hypotheses with important limitations. We predicted a higher activation of those brain areas associated with empathy networks when subjects are present. Due to increased activation within the frontal lobe, the insula and the cingulum, there are empathy-related areas active in the *person vs. object* condition. Curiously, the frontal lobes and the insula were active as well in the *object vs. person* contrast. The reason for that remain unknown. Further research has to be conducted, ideally with more participants in order to establish explanations for the neural processes of both objects and subjects conditions.
We also expected the main bystander effect to occur, namely the decrease of empathy-related brain areas with an increase in group size. And indeed, the neural brain network of empathy (mainly parts of the limbic system, frontal and temporal lobes according to Derntl et al., 2009) vanished in the contrast of *bystander vs. single.* Instead, in line with our hypothesis, a shift of attention was shown by an increased activation of the occipital gyrus and the precuneus. These brain areas were also active within the neural bystander effect study of Hortensius and de Gelder (2014), although they found increased activity in the right lingual gyrus and the left middle temporal gyrus. We found

brain regions associated with preparation for action taking in a similar manner. With the cerebellum and the supplemental motor area active, we assume that the participants' brains got prepared for an actual helping behavior. Also, the activity of the cingulum and occipital area show that bystanders trigger an increase in brain activity in areas associated with vision and perception, which falls in line again with the investigation of Hortensius and de Gelder (2014). Both of these brain networks, one responsible for showing some sort of action and one for rather passively observing, stand for the participant´s hesitation of how to handle the fact that a victim in need with witnesses present.

There are some important limitations in this study. Since only male participants were recruited, we suggest to include also female subjects in future investigations. Morevoer, an increase in sample size could provide further insight into the neural mechanisms of the bystander effect.

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APPENDIX

Che cosa fai?

(poni una crocettta sulla linea qui sotto per dire che cosa faresti in questa situazione, sapendo che più la crocetta è posta vicino a ‘non faccio nulla’ , più ti astieni dall’intervenire, mentre più la crocetta è posta vicino all’altro estremo, più intervieni nella situazione; le posizioni intermedie ti permettono di moderare la tua risposta)

What do you do?

(Place the cross below to say what you would do in this situation, knowing that the more the cross is placed close to 'do nothing', the more you refrain from intervening, while the more the cross is placed near the other end the more you´d intervene in the situation; the intermediate positions allow you to moderate your response.)

<u>SCENARIO 1</u>

Sei al mare di mattino presto e sei solo. Ti accorgi che un bagnante, che non avevi notato, viene fatto cadere a terra da una folata di vento.

You are alone at the beach in the early morning. You recognize that a swimmer, whom you have not noticed before, is dropped to the ground by a gust of wind.

Sei al mare di mattino presto e sei solo. Ti accorgi che un ombrellone, viene fatto cadere a terra da una folata di vento.

You are alone at the beach in the early morning. You recognize that a parasol get knocked over by a gust of wind.

Sei al mare di mattino presto e ci sono altre 5 persone vicino a te. Ti accorgi che un bagnante, che non avevi notato, viene fatto cadere a terra da una folata di vento.

You are alone at the beach in the early morning and there are 5 other people around you. You recognize that a swimmer, whom you have not noticed before, is dropped to the ground by a gust of wind.

Sei al mare di mattino presto e ci sono altre 5 persone vicino a te. Ti accorgi che un ombrellone, viene fatto cadere a terra da una folata di vento.

You are alone at the beach in the early morning and there are 5 other people around you. You recognize that a parasol get knocked over by a gust of wind.

<u>SCENARIO 2</u>

Stai studiando all'università la sera e sei solo. Improvvisamente si rompe la gamba di una sedia su cui è seduto uno studente che non avevi visto prima.

You are studying at the university in the evening and you are alone. Suddenly the leg of a chair breaks, on which a student, who you did not see before, sat.

Stai studiando all'università la sera e sei solo. Improvvisamente si rompe la gamba di una sedia su cui sono appoggiati alcuni libri.

You are studying at the university in the evening and you are alone. Suddenly the leg of a chair breaks on which some books were backed before.

Stai studiando all'università la sera e ci sono altri 5 studenti nella stessa aula. Improvvisamente si rompe la gamba di una sedia su cui è seduto uno studente che non avevi visto prima.

You are studying at the university in the evening with five other students in the same classroom. Suddenly the leg of a chair breaks, on which a student, who you did not see before, sat.

Stai studiando all'università la sera e ci sono altri 5 studenti nella stessa aula. Improvvisamente si rompe la gamba di una sedia su cui sono appoggiati alcuni libri.

You are studying at the university in the evening with five other students in the same classroom. Suddenly the leg of a chair breaks on which some books were backed before.

SCENARIO 3

Stai passeggiando in città il pomeriggio e sei solo, quando un motociclista scivola sul terreno bagnato e cade.

You are walking around in town by yourself in the afternoon, when the wet ground causes a rider to slip and fall.

Stai passeggiando in città il pomeriggio e sei solo, quando una moto parcheggiata sul terreno bagnato cade dal cavalletto.

You are walking around in town by yourself in the afternoon, when a parked motorcycle falls over.

Stai passeggiando in città il pomeriggio e ci sono altri 5 passanti vicino a te, quando un motociclista scivola sul terreno bagnato e cade.

You are walking by yourself into town in the afternoon and there are five pedestrians near you, when the wet ground causes a rider to slip and fall.

Stai passeggiando in città il pomeriggio e ci sono altri 5 passanti vicino a te, quando una moto parcheggiata sul terreno bagnato cade dal cavalletto.

You are walking by yourself into town in the afternoon and there are five pedestrians near you, when a parked motorcycle falls over.

SCENARIO 4

Stai camminando in città la sera e sei solo. Senti un urlo di una persona che è caduta e che non avevi notato in precedenza.

You are walking alone in town in the evening, when you hear a person, which you have not noticed before, falls on the ground and screams.

Stai camminando in città la sera e sei solo. Senti il rumore di un bidone caduto a terra.

You are walking alone in town in the evening, when you hear a can falling down to the ground.

Stai camminando in città la sera e ci sono altre 5 persone esattamente dove sei tu. Senti un urlo di una persona che è caduta e che non avevi notato in precedenza.

You are walking around in town in the evening with five other people being very near to you.
You hear someone you haven´t noticed before, screaming and falling to the ground.

Stai camminando in città la sera e ci sono altre 5 persone esattamente dove sei tu. Senti il rumore di un bidone caduto a terra.

You are walking around in town in the evening with five other people being very near to you, when you hear a can falling down to the ground.

<u>SCENARIO 5</u>

Stai sciando la mattina presto e sei solo. Noti uno sciatore che si trova più in basso sulla pista rovinare a terra per il vento.

You are skiing in the morning and you are alone. You notice that a skier located further down on the track falls on the slope for the wind.

Stai sciando la mattina presto e sei solo. Noti un cartello che si trova più in basso sulla pista rovinare a terra per il vento.

You are skiing in the morning and you are alone. You notice that a sign located further down on the track falls on the slope for the wind.

Stai sciando la mattina presto e ci sono altri 5 sciatori sulla tua stessa pista. Noti uno sciatore che si trova più in basso sulla pista rovinare a terra per il vento.

You are skiing in the morning with five other skiers on your track. You notice that a skier located further down on the track falls on the slope for the wind.

Stai sciando la mattina presto e ci sono altri 5 sciatori sulla tua stessa pista. Noti un cartello che si trova più in basso sulla pista rovinare a terra per il vento.

You are skiing in the morning with five other skiers on your track. You notice that a sign located further down on the track falls on the slope for the wind.

<u>SCNEARIO 6</u>

Stai uscendo dalla mensa mentre sta chiudendo. Sei solo. Ti accorgi che un addetto alla cucina,, non notato in precedenza, si chiude la mano nella porta d'uscita

You are coming out of the canteen, which just gets shut down. You're alone. You realize that the hand of a person who works in the kitchen, whom you have not noticed before, is trapped in the exit doors.

Stai uscendo dalla mensa mentre sta chiudendo. Sei solo. Ti accorgi che una borsa, non notata in precedenza, è chiusa tra le porte d'uscita.

You are coming out of the canteen, which just gets shut down. You're alone. You realize that a purse, which you did not noticed earlier, is trapped between the exit doors.

Stai uscendo dalla mensa mentre sta chiudendo. Ci sono altri 5 studenti vicino a te. Ti accorgi che un addetto alla cucina,, non notato in precedenza, si chiude la mano nella porta d'uscita.

You are coming out of the canteen, which just gets shut down. There are five other students around you. You realize that the hand of a person who works in the kitchen, whom you have not noticed before, is trapped in the exit doors.

Stai uscendo dalla mensa mentre sta chiudendo. Ci sono altri 5 studenti vicino a te. Ti accorgi che una borsa, non notata in precedenza, è chiusa tra le porte d'uscita.

You are coming out of the canteen, which just gets shut down. There are five other students around you. You realize that a purse, which you did not noticed earlier, is trapped between the exit doors.

<u>SCNEARIO 7</u>

Sei solo e stai camminando per strada, il pomeriggio, nei pressi di un campo da tennis. Una pallina sparata da una macchina rompe il naso di una persona a cui non avevi prestato attenzione in precedenza.

You are alone and you're walking on the street nearby a tennis court in the afternoon. A tennisball fired from a machine breaks the nose of a person who did not pay attention.

Sei solo e stai camminando per strada, il pomeriggio, nei pressi di un campo da tennis. Una pallina sparata da una macchina rompe una finestra a cui non avevi prestato attenzione in precedenza, facendo cadere pezzi di vetro sul campo.

You are alone and you're walking on the street nearby a tennis court in the afternoon. A tennisball fired from a machine breaks a window. Pieces of glass are dropping on the floor.

Stai camminando per strada, il pomeriggio, nei pressi di un campo da tennis. Ci sono altri 5 passanti. Una pallina sparata da una macchina rompe il naso di una persona a cui non avevi prestato attenzione in precedenza.

You are walking on the street nearby a tennis court in the afternoon with five pedestrians near you. A tennisball fired from a machine breaks the nose of a person who did not pay attention.

Stai camminando per strada, il pomeriggio, nei pressi di un campo da tennis. Ci sono altri 5 passanti. Una pallina sparata da una macchina rompe una finestra a cui non avevi prestato attenzione in precedenza, facendo cadere pezzi di vetro sul campo.

You are walking on the street nearby a tennis court in the afternoon with five pedestrians near you. A tennisball fired from a machine breaks a window. Pieces of glass are dropping on the floor.

SCENARIO 8

Sei d'avanti alla posta di mattina. È chiusa e sei solo, quando una folata di vento fa cadere un ramo che colpisce un passante, facendolo cadere.

You are in front of the post office in the morning. It is closed and you are alone. A gust of wind breaks a branch that hits a pedestrian, causing him to fall.

Sei d'avanti alla posta di mattina. È chiusa e sei solo, quando una folata di vento fa cadere un ramo che colpisce una bicicletta parcheggiata, facendola cadere.

You are in front of the post office in the morning. It is closed and you are alone. A gust of wind breaks a branch that hits a parked bicycle, causing it to fall over.

Sei d'avanti alla posta di mattina. È chiusa e ci sono altre 5 persone che fanno la fila con te, quando una folata di vento fa cadere un ramo che colpisce un passante facendolo cadere..

You are queuing up with five other people in front of the post office in the morning, but it is closed. A gust of wind breaks a branch that hits a pedestrian, causing him to fall.

Sei d'avanti alla posta di mattina. È chiusa e ci sono altre 5 persone che fanno la fila con te, quando una folata di vento fa cadere un ramo che colpisce una bicicletta parcheggiata, facendola cadere.

You are queuing up with five other people in front of the post office in the morning, but it is closed. A gust of wind breaks a branch that hits a parked bicycle, causing it to fall over.

SCENARIO 9

Stai viaggiando in treno la sera e sei solo, quando un'improvvisa frenata fa cadere il controllore.

You are traveling on a train in the evening by yourself, when a sudden brake causes the ticket collector to trip.

Stai viaggiando in treno la sera e sei solo, quando un'improvvisa frenata fa scivolare e cadere a terra un bagaglio dimenticato.

You are traveling on a train in the evening by yourself, when a sudden brake causes an unclaimed piece of luggage to fall down.

Stai viaggiando in treno la sera e e ci sono altri 5 passeggeri nella stessa carrozza, quando un'improvvisa frenata fa cadere il controllore.

You are traveling on a train in the evening with five other passengers in a section, when a sudden brake causes the ticket collector to trip.

Stai viaggiando in treno la sera e ci sono altri 5 passeggeri nella stessa carrozza, quando un'improvvisa frenata fa scivolare e cadere a terra un bagaglio dimenticato.

You are traveling on a train in the evening with five other passengers in a section, when a sudden brake causes an unclaimed piece of luggage to fall down.

SCENARIO 10

Ti trovi in città di mattina e sei solo. Vedi passare un ciclista che cade a terra.

You are in the city in the morning and you are alone. You see a passing cyclist fall to the ground.

Ti trovi in città di mattina e sei solo. Vedi una bicicletta appoggiata al muro che cade a terra.

You are in the city in the morning and you are alone. You see that a bicycle, leaning against the wall, fall to the ground.

Ti trovi in città di mattina e ci sono 5 passanti attorno a te. Vedi passare un ciclista che cade a terra.

You are in the city in the morning and there are five pedestrians around you. You see a passing cyclist fall to the ground.

Ti trovi in città di mattina e ci sono 5 passanti attorno a te. Vedi una bicicletta appoggiata al muro che cade a terra.

You are in the city in the morning and there are five pedestrians around you. You see that a bicycle, leaning against the wall, fall to the ground.

SCENARIO 11

Stai passeggiando in montagna la mattina presto e sei solo. Una persona che prima non avevi notato si storta una caviglia e cade.

You are hiking in the mountains early in the morning and you are alone. A person you did not notice before twists his/her ankle and falls.

Stai passeggiando in montagna la mattina presto e sei solo. Un'indicazione che prima non avevi notato, storta dall'usura, cade.

You are hiking in the mountains early in the morning and you are alone. A sign that you did not notice before, crocked by the time.

Stai passeggiando in montagna la mattina presto e ci sono altri 5 viandanti vicino a te. Una persona che prima non avevi notato si storta una caviglia e cade.

You are hiking with five other hikers near you in the mountains early in the morning. A person you have not noticed before twists his/her ankle and falls.

Stai passeggiando in montagna la mattina presto e ci sono altri 5 viandanti vicino a te. Un'indicazione che prima non avevi notato, storta dall'usura, cade.

You are hiking with five other hikers near you in the mountains early in the morning. A sign that you have not noticed before, crocked by the time.

SCENARIO 12

Sei nella toilette di un centro commerciale la mattina presto e sei da solo, quando noti una persona scivolare e cadere.

You are in the public toilet of a shopping center in the morning and you are alone, when you notice someone slip and fall.

Sei nella toilette di un centro commerciale la mattina presto e sei da solo, quando noti un dispenser del sapone staccarsi dal muro e cadere.

You are in the toilet of a shopping center in the morning and you are alone, when you notice that a soap dispenser fall off the wall.

Sei nella toilette di un centro commerciale la mattina presto e sono presenti altre 5 persone , quando noti una persona scivolare e cadere.

You are in the toilet of a shopping center in the morning and there are five other people, when you notice someone slip and fall.

Sei nella toilette di un centro commerciale la mattina presto e sono presenti altre 5 persone , quando noti un dispenser del sapone staccarsi dal muro e cadere.

You are in the toilet of a shopping center in the morning and there are five other people, when you notice that a soap dispenser fall off the wall.

<u>SCENARIO 13</u>

Stai passando la mattina allo skate-park e sei solo. Improvvisamente senti cadere uno skater a cui prima non avevi prestato attenzione.

You are spending the morning at the skate park and you are alone. Suddenly you hear that a skater, to whom you did not pay attention before, fall.

Stai passando la mattina allo skate-park e sei solo. Improvvisamente senti cadere un vecchio bidone a cui prima non avevi prestato attenzione.

You are spending the morning at the skate park and you are alone. Suddenly you hear an old bin, to which you did not pay attention before, fall over to the ground.

Stai passando la mattina allo skate-park e ci sono altri 5 ragazzi attorno a te. Improvvisamente senti cadere uno skater a cui prima non avevi prestato attenzione.

You are spending the morning at the skate park with five other skaters around you. Suddenly you hear that a skater, to whom you did not pay attention before, fall.

Stai passando la mattina allo skate-park e ci sono altri 5 ragazzi attorno a te. Improvvisamente senti cadere un vecchio bidone a cui prima non avevi prestato attenzione.

You are spending the morning at the skate park with five other skaters around you. Suddenly you hear an old bin, to which you did not pay attention before, fall over to the ground.

SCENARIO 14

Ti stai cambiando nello spogliatoio di una piscina la sera e sei solo. Uscendo dalla doccia, una persona scivola e cade a terra.

You are by yourself in the locker room of an open-air bath in the evening. Coming out of the shower, a person slips and falls to the ground.

Ti stai cambiando nello spogliatoio di una piscina la sera e sei solo. La tenda della doccia si sgancia e cade a terra.

You are by yourself in the locker room of an open-air bath in the evening. Then, the shower curtain releases itself and falls to the ground.

Ti stai cambiando nello spogliatoio di una piscina la sera e ci sono altri 5 nuotatori. Uscendo dalla doccia, una persona scivola e cade a terra.

You are with five other swimmers in the locker room of an open-air bath in the evening. Coming out of the shower, a person slips and falls to the ground.

Ti stai cambiando nello spogliatoio di una piscina la sera e ci sono altri 5 nuotatori. La tenda della doccia si sgancia e cade a terra.

You are with five other swimmers in the locker room of an open-air bath in the evening. Then, the shower curtain releases itself and falls to the ground.

SCENARIO 15

Sei in biblioteca di mattina presto e sei solo, quando un lettore che non avevi notato prima ha un capogiro e cade.

You are in the library early in the morning and you are alone, when a reader, whom you have not noticed before, gets dizzy.

Sei in biblioteca di mattina presto e sei solo, quando un volume che non avevi notato prima cade.

You are in the library early in the morning and you are alone, when a book, which you have not noticed before, falls out of a book shelf.

Sei in biblioteca di mattina presto e nei tuoi pressi ci sono altri 5 lettori, quando un lettore che non avevi notato prima ha un capogiro e cade.

You are with five other students in the library early in the morning, when a reader, whom you have not noticed before, gets dizzy.
Sei in biblioteca di mattina presto e nei tuoi pressi ci sono altri 5 lettori, quando un volume che non avevi notato prima cade.

You are with five other students in the library early in the morning, when a book, which you have not noticed before, falls out of a book shelf.

SCENARIO 16

Ti trovi in una corsia di un grande magazzino e sei solo, quando senti una persona, che non avevi visto, inciampare e cadere.

You are in an aisle of a department store and you are alone, when you hear a person, which you did not see before, trips and fall.

Ti trovi in una corsia di un grande magazzino e sei solo, quando senti una confezione, che non avevi visto, cadere.

You are in an aisle of a department store and you are alone, when you notice that a product you did not pay attention to before, falls out of the shelf to the ground.

Ti trovi in una corsia di un grande magazzino e sono presenti altri 5 acquirenti, quando senti una persona, che non avevi visto, inciampare e cadere.

You are in an aisle of a department store with five other customers around you, when you hear a person, which you did not see before, trips and fall.

Ti trovi in una corsia di un grande magazzino e sono presenti altri 5 acquirenti, quando senti una confezione, che non avevi visto, cadere.

You are in an aisle of a department store with five other customers around you, when you notice that a product you did not pay attention to before, falls out of the shelf to the ground.

CURRICULUM VITAE

Persönliche Daten	
Name	Florence Schmoll
Nationalität	Österreich, Schweiz
Schulische Ausbildung	
1996 – 2000	Volksschule Oedt, Linz-Land
2000 – 2004	Realgymnasium Traun, Linz-Land
2004 – 2009	Höhere Bundeslehranstalt für wirtschaftliche Berufe, Linz *Maturaabschluss mit ausgezeichnetem Erfolg*
Studium	
WS 2009	Beginn des Diplomstudium Psychologie, Wien
SS 2011	Abschluss des 1. Abschnitts Schwerpunkt: Klinische Psychologie
SS 2014	Beginn der Diplomarbeit; Titel: „*The bystander effect and its underlying neural mechanisms“*
Auslandsaufenhalte	
Juli 2012	Ehrenamtliches Praktikum, Bradford, Vereinigtes Königreich
Juli – August 2013	Praktikum in der Psychiatrischen Tagesklinik Lörrach, Lörrach, Deutschland
August – Dez. 2014	Auslandssemester an der University of South Carolina, Columbia, Vereinigte Staaten von Amerika

Studiumsbezogene Nebentätigkeiten

Mai – Juni 2012	Ausbildung bei Verein „Zeit! Raum“ als Patin für Jugendliche aus einem problematischen, sozialen Umfeld, Wien
seit Juni 2014	freie wissenschaftliche Projektmitarbeiterin von Dr. MSc Sabine Urbanits, Neurologin am Kaiser-Franz-Josef-Spital, Wien