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Pupil mimicry and trust – Implication for depression

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ABSTRACT

Individuals suffering from depression often have difficulty trusting others. Previous research has shown a relationship between trust formation and pupil mimicry - the synchronization of pupil sizes between individuals. The current study therefore examined whether pupil mimicry is weaker in depressed individuals and an underlying factor of their low levels of trust. Forty-two patients with major depressive disorder (MDD) and 40 healthy control subjects played trust games with virtual partners. Images of these partners' eye regions were presented to participants before they had to make a monetary investment decision. Partners' pupils either dilated, constricted, or remained static over the course of 4-s interactions. During the task, participants' pupil sizes were recorded with eye-tracking equipment to assess mimicry. The results confirm that patients with MDD were somewhat less trusting than controls and used another's pupillary cues differently when deciding to trust. Specifically, whereas healthy controls trusted partners with dilating pupils more than partners with constricting pupils, patients with MDD particularly trusted partners whose pupils changed in size less, regardless of whether partners' pupils were dilating or constricting. This difference in investment behavior was unrelated to differences in pupil mimicry, which was equally apparent in both groups and fostered trust to the same extent. Whereas lower levels of trust observed in patients with MDD could not be explained by differences in pupil mimicry, our data show that pupil dilation mimicry might help people to trust. These findings provide further evidence for the important role of pupil size and pupil mimicry in interpersonal trust formation and shed light on the pathophysiology of clinically low trust in patients with MDD.

1. Introduction

The ability to trust others is pivotal to social life, yet patients with depression have difficulties in trusting others (Kupferberg et al., 2016). In contrast to healthy individuals, they do not have the positive expectation that sharing emotions with others fosters help and cooperation (Lewis and Weigert, 1985). In our daily lives, we often have to assess trustworthiness in strangers. In order to evaluate a counterpart's trustworthiness, we rely on various indicators of a safe interaction, such as emotional expressions, bodily gestures, or group membership (Dunn and Schweitzer, 2005; Oosterhof and Todorov, 2008).

Patients with depression have been shown to focus on their internal world and have impaired social skills (Segrin, 2000; Silk et al., 2008), which include deficits in emotion recognition (Kret and Ploeger, 2015), the avoidance of eye contact (e.g., Segrin, 2000), impaired theory of mind abilities (Koelkebeck et al., 2017)and difficulties in building trustful relationships (Lester and Gatto, 1990; Muris et al., 2001). The ability to process signals of trust and translate them into behavior seems impaired, which might also be related to patients' lower levels of cooperation, relatively egocentric behavior, and limited perspective-taking ability (Brendan Clark et al., 2013; Cusi et al., 2013).

Previous studies that showed deficits in emotion processing in depressed patient groups mainly included stimuli with explicit, prototypical facial expressions (Rubinow and Post, 1992; Gilboa-Schechtman et al., 2002; Langenecker et al., 2005; Gollan et al., 2008; Kret and Ploeger, 2015). Conversely, expressions in real life are usually more ambiguous and subtle, yet sufficient to foster trust and social support (Kret, 2015; Aviezer et al., 2012). Direct eye contact provides the most powerful mode of sharing subtle expressions.

For humans, eyes do not only have a visual function, but also serve

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Table 1
Demographics and test scores of participants.

	Mean (SD)		Mean differences	
	MDD group (N = 42)	Control group (N = 40)	χ^2 / *t* / *F* test values	*p* value
Gender (m/f)	23/19	23/17	χ^2 (1) = 0.062	0.803
Age	39.26 (11.46)	39.73 (10.91)	*t* (80) = 0.187	0.852
HDRS	14.61 (5.83)[a]	0.65 (1.14)	*t* (79) = 14.864	**< 0.001**
Duration of illness (in years)	3.33 (5.19)	–	–	–
EQ	47.40 (40.89)	42.15 (37.98)	*t* (80) = 0.602	0.549
Arousal	2.399,598 (115.46)	1.775,887 (119.81)	*F* (1, 4.309) = 14.051	**< 0.001**
Reaction time	1.42 (0.73)	1.28 (0.75)	*F* (1, 4412) = 1.952	0.162
School years	11.57 (1.52)	11.80 (1.49)	*t*(80) = 0.688	0.493
IQ (MWTB)	107.64 (12.09)	116.83 (16.41)	*t*(80) = 2.894	**0.005**

HDRS: Hamilton Depression Rating Scale (21 items, (32)): measures depressive symptoms.
EQ: Empathy Quotient (60 items, (34)): measures empathic abilities in adults.
Arousal: Participants' stimulus-unrelated pupil size, i.e., participants' average pupil size 200–400ms prior to stimulus onset. The stimulus-unrelated pupil size might indicate participants' general level of arousal unrelated to the stimulus material.
IQ MWTB: Multiple Choice Vocabulary Test (35): measures premorbid intelligence.
Note: Significant differences are marked bold.
[a] Score of one participant is missing.

as a reference point to be seen by others (Tomasello et al., 2007). The pupil dilates or constricts not only in response to different lighting conditions, but also in response to emotion and thought (Goldwater, 1972; Loewenfeld, 1993; Laeng et al., 2012). By observing the pupil, significant information about the emotional, mental or cognitive state of another person can be acquired (Kahneman and Beatty, 1966). Because pupillary responses are autonomic and uncontrollable (Loewenfeld, 1993), they can provide important and reliable social information to observers. Several studies using pupillometry demonstrated pupil dilation upon viewing pictures with arousing or emotionally relevant stimuli (Peavler and McLaughlin, 1967; Kret et al., 2013a, 2013b). Furthermore, larger pupil sizes are associated with increased approach behavior and attractiveness in humans (Laeng and Falkenberg, 2007; Wiseman and Watt, 2010) and yield honest, non-deceptive behaviours (van Breen et al., 2018).

Recently, it has been shown that people implicitly mimic the pupil size of their interaction partners (Kret et al., 2015) and that paying attention to other peoples' pupils and mimicking their changes in size helps to determine the trustworthiness of a partner (Kret et al., 2015; Kret and de Dreu, 2017). In these two studies, healthy individuals trusted partners with dilating pupils more than partners with static pupils and, especially so, when their pupils synchronized, i.e., when participants' pupils dilated along with the dilating pupils of the partner (Kret and de Dreu, 2017; Kret et al., 2015). Thus, participants based assessments of trustworthiness on their partners' pupil size. This stresses the relevance of pupil mimicry in the establishment of trust and suggests that a lack of pupil mimicry could account for lower levels of trust (Kret et al., 2015). From that point of view, we may hypothesize that lower levels of trust in depressed individuals (Lester and Gatto, 1990) stem from a failure to mimic the pupil sizes of interaction partners. That is, patients might fail to implicitly infer trust from own and others' pupil sizes.

In sum, a major characteristic of depression is its impairment in social functioning, including a lack of trust in others (Lee et al., 2005; Muris et al., 2001). Although these difficulties in depressed individuals are pervasive, a detailed understanding of the cognitive mechanisms underlying these deficits has not been reached. Because recent research findings point to an important role of pupil mimicry in social interaction and trust decisions in particular (Kret et al., 2015), the pupil is introduced to contribute to a better understanding of depression.

The current study examined the relationship between pupil mimicry and trust in patients with a clinically diagnosed episode of a major depressive disorder (MDD) as compared to a healthy control group. First, it was examined whether the participants' pupil sizes synchronize with a partner's dilating or constricting pupils as compared to partner's static pupils. Second, it was tested whether there is a difference in pupil mimicry between depressed individuals and healthy controls and third, whether pupil mimicry influences trust decisions in the two groups.

2. Methods and materials

2.1. Participants and clinical assessment

A total of 106 participants were recruited from the University Hospital Muenster, Department of Psychiatry and Psychotherapy, Germany. The sample included 64 patients with a single or recurrent episode of MDD and 42 healthy controls.

In total, nineteen patients had to be excluded. Six patients were excluded due to a concurrent anxiety disorder, two due to concurrent severe personality disorder, three due to technical issues, three due to not meeting criteria for a depressive episode any longer and five patients due to not meeting a major depressive episode as regarding the DSM-criteria. In addition, two control participants were excluded because they had a lifetime diagnosis of MDD or panic disorder. Three other participants were excluded because they could not complete the task due to technical difficulties. Therefore, the statistical analyses are based on a sample size of 42 patients with MDD (*mean age* = 39.26, *SD* = 11.45) and 40 healthy controls (*mean age* = 39.56, *SD* = 11.00). There were no significant differences between the two groups in terms of age ($t(80) = 0.187$, $p = 0.852$), gender (χ^2 (1) = 0.062, $p = 0.803$), or years of education ($t(80) = 0.688$, $p = 0.493$; see Table 1 for an overview of all demographic variables). While patients volunteered, controls received a compensation of €20, following standard guidelines of the local ethics committee. All participants took part in the Structured Clinical Interview for DSM-IV (First et al., 1996) to confirm patients' diagnoses of MDD and to rule out any other mental disorders in patients and control subjects. For patients, all Axis-I disorder other than depression or severe Axis-II mental disorders qualified as exclusionary criteria. Furthermore, the Hamilton Depression Rating Scale (Hamilton, 1967) was conducted to rate depressive symptoms and their severity in both groups. Thirty-five of the patients in the final sample received antidepressant or mood-stabilizing medication (SNRI: 7; SSRI: 6; NaSSA: 5; NDRI: 4; tricyclic antidepressant: 2; MAO-inhibitor: 1; mood stabilizer: 1; atypical antipsychotic: 1; two-fold combination of SNRI and NaSSA: 4; NDRI and melatonin-derivative: 1; SSRI and melatonin-derivative: 1; three-fold medication of SNRI, NaSSA and melatonin-