Decision-making and personality characteristics of patients with major depressive disorder following a suicide attempt

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I. ABBREVIATIONS

ANOVA	univariate analysis of variance
BIS	Barratt Impulsiveness Scale
C	cooperativeness
DLPFC	dorsolateral prefrontal cortex
DMPFC	dorsomedial prefrontal cortex
DSM-5	Diagnostic and Statistical Manual of Mental Disorders (5^{th} ed.)
H	hypothesis
HA	harm avoidance
HAM-D	Hamilton Depression Rating Scale
HC	healthy control individuals
ICD	International Classification of Diseases
IGT	Iowa Gambling Task
MANCOVA	multivariate analysis of covariance
MANOVA	multivariate analysis of variance
N	number
NS	novelty seeking
OFC	orbitofrontal cortex
P	persistence
RD	reward dependence
SA	suicide attempt
SD	standard deviation
S-D	self-directedness
SPSS	Statistical Package for Social Sciences
T	transcendence
TCI	Temperament and Character Inventory
VMPFC	ventromedial prefrontal cortex

II. SCOPE OF THE THESIS

A suicide attempt occurs in a complex bio-psycho-social context. Psychological components are among the most relevant risk factors for suicidal behaviour, and can be influenced by the healthcare system. Therefore, a focus on these variables can be important in a psychiatric setting.

There is a broadening knowledge about the psychological alterations related to suicidal behaviour; although, most studies report the characteristics of individuals with a lifetime history of a suicide attempt, which mostly facilitates to draw conclusions about trait-like aspects. Indeed, observing definite state-dependent features of suicidal crisis is one of the greatest issues of this field. Better understanding of the alterations featuring suicidal behaviour would be essential; however, measuring the period preceding the suicide attempt is challenging. Capturing individuals' state of mind within a tight time frame following their suicide attempt seems to be a suitable solution.

Thus, the present study aimed to explore certain cognitive and personality factors among medication-free individuals with major depressive disorder within 72 hours following their suicide attempt. Since these persons were enrolled in this research in quite a sensitive state, selection of well-founded variables was crucial. Hence, decision-making as a cognitive function and impulsivity, temperament and character factors as personality components were chosen to be observed.

The thesis comprises the results of two original research articles. The first paper's main goal was to report the comprehensive decision-making profile of depressed participants with a recent suicide attempt and healthy control individuals. To broaden our scope, the second article took personality components also into account, and then examined the possible interplay and relevance of these variables.

III. INTRODUCTION

1. Description, definitions and differential diagnosis

Suicide is a universal and multidimensional issue of mankind concerning social, spiritual, legal, philosophical, psychological and medical aspects. The word ‘suicide’ stems from the Latin terms “sui” meaning self and ‘caedes’ meaning death. However, reflecting this phenomenon contributes not only to the understanding of the individual level of deliberate self-harm, but opens a window to the awareness of suicide as the matter of humanity (Kumar, 2017). Judgement of suicide varied among different cultures and over centuries from a heroic to a sinful, criminal act and still shows differences among various regions of the world (Koslow et al., 2014). As regards Western cultures, suicide was de-criminalized and reframed mainly as an issue of the healthcare system.

Since judgement of suicide varies among nations and religions, there is no unitary classification system and nomenclature for suicide and suicidal behaviour, which raises methodological concerns in the scientific literature. Therefore, it is essential to clarify the definitions accepted within this thesis.

Suicide can be described as a fatal act of taking one’s own life with some evidence of intent to die (Koslow et al., 2014; Turecki & Brent, 2016), and it is differentiated from euthanasia and suicide terrorism due to their distinct motivational background. However, several other forms of suicidal behaviour and self-harm are present. *Active or passive suicide ideation* refer to thoughts about death of which the *active* form includes specific and explicit concepts about taking action of end one’s life, while the *passive* form includes phantasies about non-existence and death, but actual intent and plans are not present (Turecki & Brent, 2016). *Non-suicidal self-injury* can be described as a self-injurious behaviour with no intent to die and includes repetitive cutting and picking for example (Turecki & Brent, 2016). *Suicide attempt* is a non-fatal self-directed potentially injurious behaviour with an intent to die as a result of this act (Koslow et al., 2014). Finally, *suicidal behaviour* refers to suicide and suicide attempt.

2. Epidemiology

Suicide is a major public health problem worldwide as regards it takes approximately 800 000 lives per year and therefore considered as one of the leading causes of death [World Health Organization (WHO), 2019]. However, suicide rates vary between regions representing distinct economic status and cultural differences, and show diversity among various demographic groups. The number of completed suicides is around 59 000 in the European countries per year (Miret et al., 2013). Suicide is an especially serious issue in Hungary: from 1960' to 1980' suicide rates were the highest in this country (Bachmann, 2018) and despite of the considerable decrease in the number of suicides, Hungary is still listed among the most affected countries with its 19.1 death by suicide per 100 000 (WHO, 2019). The latest update of Eurostat Data Browser (2021) demonstrate that Hungary is the 5th among European countries based on suicide rates in the general population. Considering different age groups, 4.21 deaths by suicide per 100 000 was observed between 15 and 19 years of age, 15.95 from 50 to 54 years of age and 24.04 over 85 years of age in the European Union. Rates of suicide deaths are higher among men: 17.76 per 100 000 was reported among men and 4.66 per 100 000 was reported among women in this region with the same tendency in Hungary (29.23 versus 7.22 per 100 000, Eurostat Data Browser).

Concerning suicidal thoughts and suicidal behaviour, worldwide lifetime prevalence of suicide ideation is 9.2%, which number is 2.7% regarding suicide attempts (Turecki & Brent, 2016). In Europe, 10-30 attempts were reported for each completed suicide (Bachmann, 2018). Considering that a suicide attempt is one of the most important risk factors for a completed suicide (Yoshimasu et al., 2008) and the strongest risk factor for a further suicide attempt (Jollant et al., 2011), this is a noteworthy data. However, different sociodemographic tendencies can be observed in comparison to completed suicides, since higher rates of suicide ideation and attempt were reported among women (Turecki & Brent, 2016).

3. Course and prognosis

Suicidal behaviour can occur at any time in the lifespan; however, it is rarely seen in young children (DSM-5, 2013) and reaches the highest absolute numbers in younger age

(Bachmann, 2018). As for the rate of suicide deaths per 100 000 among the Unites States and Hungary, peaks can be seen in middle age (45-64/56-64) and in elderly (85/75 age or older) (Hedegaard, 2020; Rihmer et al., 2013; WHO Mortality Database, 2021).

Although, reliable national statistics about non-fatal forms of suicidal behaviour is unknown, there are some data about their poor prognosis: 60% of suicide attempts occurs within 1 year following the onset of suicidal ideation (Kessler et al., 2003; Nock et al., 2008) and a suicide attempt indicates high risk for both repeated attempt(s) and a completed suicide (Bachmann, 2018). Some data suggest that the likelihood of suicide death is higher in the year following a previous attempt (Reid, 2009). Besides, suicidal ideation and attempted suicide can associate with injuries, hospitalization and loss of liberty (Klonsky et al., 2016). Overall, prevention programs should target individuals with a lifetime history of a suicidal behaviour in order to a better prognosis.

4. Risk factors

Besides lifetime history of a suicide attempt, numerous further significant risk-factors have been identified so far in the background of a suicide attempt: for instance, presence of a psychiatric illness, substance abuse, adolescent or advanced age, male gender, unmarried status, lower educational level, rurality and economic crises. Rihmer (1996) classifies these factors as primary, secondary and tertiary factors, of which effect of the primary factors (i.e. suffering from a mental illness, previous suicide attempt or family history of a suicide attempt, suicidal intent, low serotonergic activity) can be influenced by the healthcare system. However, secondary (i.e. early parental loss, social isolation, financial problems, adverse life events) and tertiary factors (i.e. male gender, adolescence and advanced age, vulnerable periods) are also related to primary factors, meaning that their effect is lower on suicidal risk with the absence of the primary factor. According to another perspective, individual- or population-level risk factors should also be differentiated (Sinyor et al., 2017; Turecki & Brent, 2016) in order to find distinct ways of prevention. For example, adverse early life events, certain personality traits and family history are distal individual-level risk factors, while having a psychiatric illness, substance intoxication and stressful life events are proximal individual-level factors.

Rurality, economic crises and social fragmentation are highlighted as population-level elements (Sinyor et al., 2017).

Overall, it can be seen, that suicide is a complex multi-causal phenomenon. These classifications list both biological, psychological, sociodemographic and economic components and argue that modifiable risk factors concern different areas of the care system. This introduction focuses on biological and psychological factors, since they can be managed by the healthcare system.

The first decisive models revealing biological and psychological variables in the background of suicidal behaviour – including Baumeister's escape model, Beck's cognitive model, Mann's clinical model and Williams's arrested flight model (for details see Barzilay & Apter, 2014; O'Connor & Nock, 2014) – highlighted the relevance of particulate factors. Stress-diathesis models aim to reveal the interrelation of the most significant components. In general, a psychiatric disease or a behaviour (e.g. suicide attempt) may emerge in those individuals, who are vulnerable for it and experience some relevant stressors. Level of vulnerability mediates how serious stressor could trigger the disease or behaviour – with more predisposing factors a minimal stress-factor could induce the abnormal state (van Heeringen, 2012). Childhood abuse, neuroanatomical, physical and genomic alterations (e.g. alterations of the serotonergic system, structural and functional brain changes) are regarded as vulnerability components, while an ongoing psychiatric illness's correlates (e.g. severe depressive symptoms, hopelessness, affected cognitive functioning) and psychosocial adversities (e.g. social isolation, unemployment status) could be relevant stress factors of suicidal behaviour (van Heeringen, 2012). However, this list is not exhaustive. Detailed presentation of these components can be found in the following sections.

4.1. Diathesis factors

Detailing diathesis factors, genetic studies proved that approximately 30-50% of the risk for suicidal ideation and behaviour and 17-45% of the risk for attempted suicide is heritable (Mann et al., 2009). Heritability of suicidal behaviour transmitted independently of psychiatric diseases (Mann et al., 2009; Turecki et al., 2019). Family history of a suicide increases the risk of suicide by 2-4.8 times. Furthermore, higher concordance can be observed among

monozygotic twins in comparison to dizygotic twins, and adaptation studies confirm stronger association between adoptees and biological relatives, than adoptees and adoptives concerning suicidal behaviour (Mann et al., 2009). However, environmental vulnerability factors including adverse early life-events also have a considerable role in suicide.

In spite of the convincing evidence of heritability and the intensive genetic research, there have not been a single gene or group of genes identified in the background of suicidal behaviour (Turecki et al., 2019). However, bearing in mind the importance of replicating certain GWAS studies, some possibly relevant gene variants (e.g. COL606, BACE1) can be detected (Turecki et al., 2019).

Concerning neurobiological aspects, alterations of the serotonergic system can be highlighted as an important vulnerability factor for suicide, mediating by gene expression of 5-HIAA, 5-HT2A, monoamine oxidase A, tryptophan hydroxylase (Mann et al., 2009). Besides, chronic abnormalities of the hypothalamic-pituitary-adrenal system can be mentioned as a diathesis component – for example resulting in elevated 24 hours cortisol levels of suicidal individuals (Perna & Schatzberg, 2014). Decreased expression of neurotrophic genes (e.g. BDNF), alterations of the GABAergic and glutamatergic system, and the role of inflammatory responses can also be observed among individuals with suicidal behaviour (Turecki et al., 2019).

Regarding the "suicidal brain", functional and structural changes of the orbitofrontal cortex (OFC), dorsolateral prefrontal cortex (DLPFC) (Jollant et al., 2011; van Heeringen et al., 2011), dorsomedial prefrontal cortex (DMPFC), anterior cingulate gyrus, amygdala and the medial temporal cortex (Jollant et al., 2011) associate with suicidal behaviour.

4.2. Stress factors

4.2.1. Mental disorders

Suicidal behaviour rarely occurs among individuals with no discernible pathology (DSM-5, 2013); thus, suffering from a mental disorder or a serious physical condition (e.g. cancer, multiple sclerosis, Gunnell & Lewis, 2005) can be observed to be associated with increased risk for it.

Psychiatric illnesses should be highlighted and referred as one of the most relevant stress factors, since 90% of individuals who attempted suicide experience a mental disorder (Rihmer, 2007). Among them, suicidal behaviour arises most commonly in the context of major depressive disorder, bipolar disorder, schizophrenia and schizoaffective disorder, anxiety disorders, substance use disorders, borderline and antisocial personality disorders and eating disorders (DSM-5, 2013).

The role of an ongoing depressive episode can be specifically high, since it is present in 56-87% of suicide completers (Rihmer, 2007). However, it is important to note that experiencing a depressive episode is not inclusive for major depressive disorder. For example, at least one major depressive episode is needed for the diagnosis of bipolar disorder. Regarding that several different psychiatric conditions with different pathogenesis show comorbidity with suicidal behaviour, narrowing the viewpoint could be essential. The study presented in this thesis focused on major depressive disorder, which is an important target population for suicide prevention since lifetime prevalence of suicide attempt is approximately 31% in it (Dong et al., 2019).

According to the DSM-5 (2013), diagnosis of major depressive disorder requires at least 5 symptoms lasting for at least 2 weeks among the followings, including (1) and / or (2): (1) depressed mood, (2) loss of interest or pleasure, (3) significant changes in weight and appetite, (4) insomnia or hypersomnia, (5) affected psychomotor functions, (6) fatigue or loss of energy, (7) feelings of worthlessness or guilt, (8) concentration or decision-making deficits, (9) suicidal ideation. This state should cause a significant distress and dysfunctions of important life areas and it cannot attribute to substance abuse or another medical conditions. Furthermore, it should be observed whether this episode is not better explained by schizophrenia spectrum disorders. Finally, exclusion of bipolar I and II disorder (i.e. occurrence of an anamnestic manic or hypomanic episode) is crucial.

It is important to note that currently, discussing mental disorders as relevant stress factors for suicidal behaviour is a correct approach, but reframing this concept could become necessary in the future. Suicidal behaviour had not been included as an independent diagnostic category in the manuals of mental disorders yet; but the DSM-5 (2013) deals with “suicidal behaviour disorder” as a possible individual future condition, which requires further study. Therefore, these disorders could be regarded as comorbid conditions in the future.

4.2.2. Psychological risk factors

First and foremost, it is important to highlight that certain psychological components may represent trait-like characteristics; however, controversial findings are present. Thus, clear distinction of them among vulnerability or stress factors remained unresolved, but they are generally clustered among stress-factors.

Regarding neuropsychological components, deficits in cognitive inhibition (Richard-Devantoy et al., 2012), cognitive flexibility (Keilp et al., 2001), working-memory (Keilp et al., 2014), fluency (Audenaert et al., 2002; Keilp et al., 2001), attention (Keilp et al., 2013; Keilp et al., 2001; Keilp et al., 2008), (autobiographical) memory (Keilp et al., 2014), problem-solving (Pollock & Williams, 2004) and decision-making (Jollant et al., 2005) have been reported so far in persons with a suicide attempt, but this list is not exhaustive. These factors can be also present during major depressive disorder per se, but can differentiate individuals with a lifetime history of a suicide attempt from psychiatric control persons without a previous attempt. For instance, decision-making (Jollant et al., 2005), working-memory, attention and memory (Keilp et al., 2014) deficits are observed to be heightened in individuals with a lifetime history of a suicide attempt in comparison to affective controls. This tendency was also proved by meta-analyses: deficits affecting decision-making, categorical fluency and attention switching / inhibition (Richard-Devantoy et al., 2014) and decision-making (Perrain et al., 2021) were proved to be pronounced in suicidal behaviour among the most relevant cognitive risk factors.

As for personality factors, reviews of this field asserts that hostility (Brezo et al., 2006), impulsivity (Brezo et al., 2006; Giner et al., 2016), hopelessness (Brezo et al., 2006; Giner et al., 2016; Ribeiro et al., 2018); neuroticism and extraversion among the five-factor components (Brezo et al., 2006; Giner et al., 2016); and harm avoidance, novelty seeking, cooperativeness and self-directedness from Cloninger's temperament and character factors (Giner et al., 2016) are regarded as the most relevant personality correlates of suicidal behaviour.

The present study focuses on decision-making, impulsivity and Cloninger's temperament and character factors from the above mentioned psychological components, which

will be presented in separate chapters. These variables were reported among the most relevant psychological risk factors for suicide attempts.

5. Decision-making

Decision-making refers to a process resulting in choices in uncertain situations when more options are available. It is a complex function, which requires proper perception of a given situation, reward-based evaluation of possible choices, action depending on the decision-maker's needs, and re-evaluation of decisions based on the outcome (Doya, 2008). The specificity of this dysfunction in suicidal behaviour was firstly reported by Jollant et al. (2005), who found that individuals with a violent suicide attempt underperformed in a decision-making task compared to non-suicidal subjects with affective disorders and healthy controls. Possible role of decision-making was originally hypothesized due to serotonergic impairments in the orbitofrontal cortex (OFC) / ventromedial prefrontal cortex (VMPFC) in suicidal individuals (Mann et al., 1999), since these areas play an important role in this function (Bechara et al., 1994). It should be mentioned, that OFC and VMPFC are partially overlapping, densely interconnected areas, which are responsible for similar functions; therefore, clear differentiation of them could be difficult in clinical studies (Pujara & Koenigs, 2014; Zald & Andreotti, 2010). Hence, they are referred as OFC / VMPFC in this thesis.

Though the OFC / VMPFC were highlighted to be responsible for decision-making, it is necessary to note that complexity of this function indicates an extended neural circuit, which includes the DLPFC, amygdala, striatum (Clark et al., 2004; Naqvi et al., 2006; Pujara & Koenigs, 2014), brainstem and insula (Naqvi et al., 2006; Phelps et al., 2014).

Besides Jollant et al. (2005), several further studies measuring different suicidal subgroups and using different tasks confirmed that decision-making has an important role in suicidal behaviour (Bridge et al., 2012; Clark et al., 2011; Deisenhammer et al., 2018; Malloy-Diniz et al., 2009; Oldershaw et al., 2009; Westheide et al., 2008). A meta-analysis supported the association between suicidal behaviour and poor decision-making performance in unipolar and bipolar patients as well (Richard-Devantoy et al., 2015). Furthermore, decision-making deficit was found in healthy first-degree relatives of suicide completers compared to healthy and depressed control subjects with no familial history of a suicide attempt, suggesting that this

impairment may be a cognitive endophenotype of suicidal behaviour (Hoehne et al., 2015). However, Gorlyn et al. (2013) highlighted that the majority of these studies reported decision-making deficit in specific subgroups (i.e. individuals with a violent attempt or a past attempt with current suicidal ideation); therefore, it cannot be a global marker for it.

According to the classification of Phelps et al. (2014), different tasks capture different aspects of decision-making. One of the most often used decision-making tasks is the Iowa Gambling Task (IGT, Bechara et al., 1994), which was developed to simulate real-world decision-making processes in ambiguous and risky situations. During this computerized card game, participants can choose cards from four decks, which are followed by different amount of immediate rewards and sometimes also by money losses. The goal of the game is to gain as much money as possible. Subjects need to recognize that some decks are disadvantageous in the long-term, since their high rewards are associated with even higher losses; while the others are more beneficial with their lower rewards followed by moderate punishments. Thus, for a better performance, participants have to refuse higher immediate rewards.

Given that rejection of high rewards is essential for a better future outcome, one obvious explanation for poor performance on this task can be hypersensitivity to reward; and on the other hand, decreased sensitivity to punishment can also contribute to the preference for risky decks (Bechara et al., 1994). Nonetheless, the original test does not allow the understanding of the complete background of disadvantageous decisions; thus, a modified version of the IGT was designed for the possibility of a broader interpretation (Bechara et al., 2000). The main differences between the original ("ABCD") and the modified ("EFGH") version are that in the latter one, the choosing of cards is followed by immediate punishments, and the addition of rewards is occasional. Decks with higher losses provide even higher rewards; therefore, these are advantageous in the long-term. In their study, Bechara et al. (2000) reported that patients with OFC / VMPFC lesion performed poorly on both versions of the IGT, which raises that an alternative explanation is needed instead of those limited to the sensitivity to reward or punishment. In the case of this patient group, insensitivity to future consequences may underlie decision-making deficit (Bechara et al., 2000). These findings are in line with patients' complaints about their sequential disadvantageous decisions, which affect their social life negatively (Bechara et al., 2000).

Even though the comprehensive interpretation of decision-making function requires both versions, the IGT EFGH performance of persons with suicidal behaviour is not known. From the presented study's point of view, results of patients with major depressive disorder could be informative: a study reported that this group performed poorly on the ABCD version, but had a normal learning rate on the EFGH (Must et al., 2006). These individuals may have increased reward-sensitivity (or decreased punishment-sensitivity) or preference for decks with higher emotional valence due to their reduced emotional reactivity (Must et al., 2006; Must et al., 2013). Nonetheless, decision-making deficit of depressed patients with no history of suicidal behaviour was not consequently reported: Jollant et al. (2005) found poor performance of participants with a past suicide attempt on the IGT ABCD, but did not observe this alteration in the affective control group.

6. Temperament and character components, impulsivity

6.1. Impulsivity

Impulsivity is a multifactorial, partly heritable construct (Baud, 2005) referring to different forms of impaired self-regulation (Kumar, 2017). It is usually measured by self-report or neuropsychological tests grasping its behavioural or personality aspects. Although impulsivity has a complex neurobiological basis, it strongly associates with the serotonergic system via 5-HT activity (Baud, 2005) and the dopaminergic system (Congdon & Canli, 2008).

As a personality component, impulsivity can refer to a lack of deliberation and persistence (Kumar, 2017); novelty seeking behaviour, rapid processing of information and the inability to delay gratification and to forethought before acting (Carli et al., 2010). Its different facets can be measured by different personality tasks, such as motor, cognitive / attentional and non-planning impulsivity (Barratt, 1959; Patton, 1995) and deficits in conscientiousness, sensation seeking and negative urgency (Cole et al., 2019).

Since impulsivity could indicate the lack of a well-balanced functioning, it could associate with personality disorders from the "dramatic" cluster, attention deficit hyperactive disorder, conduct disorder (Moeller et al., 2001), substance abuse, behavioural problems, affective disorders and suicidal behaviour (Swann et al., 2008). Although the role of impulsivity

is often highlighted in manic state, important interrelation of non-planning impulsivity and depressive state was also found (Swann et al., 2008). Furthermore, heightened behavioural and cognitive impulsivity could be specific to suicidal behaviour, since significant difference were present concerning these aspects among depressed individuals with or without a recent suicide attempt (Corruble et al., 2003).

Importance of impulsivity on suicidal behaviour was verified by further studies as well (Cole et al., 2019; Klonsky et al., 2016; Nock et al., 2008; Pompili, 2008; Ponsoni et al., 2018). However, inconsistent results are also present (Carli et al., 2010). Some authors raised the possibility of distinct role of impulsivity among certain suicidal subgroups. Zouk et al. (2006) differentiated impulsive and non-impulsive suicidal individuals and reported distant personality profiles of these groups; while McGirr et al. (2008) highlighted the importance of age, since impulsivity seemed to play a greater role in suicidal behaviour among younger persons.

6.2. Temperament and character components

Different approaches highlight distinct aspects when defining „personality"; however, according to most theories, personality includes sets of habitual behaviours, cognitions and emotional patterns, which evolves from biologically innate components with the influence of environmental factors (Corr & Matthews, 2009). From the psychobiological point of view, Cloninger defines personality as the „dynamic organization within the individual of the psychobiological systems by which the person both shapes and adapts uniquely to an ever-changing internal and external environment" (Zwir et al., 2019).

Cloninger's psychobiological model went on a gradual development and now four temperament (harm avoidance, novelty seeking, reward-dependence, persistence) and three character factors (self-directedness, cooperativeness, transcendence) can be differentiated. Temperament is a partially heritable "disposition of a person to learn how to behave, react emotionally, and form attachments automatically by associative conditioning"; while character refers to the self-regulatory aspects of personality which also show heritability and link to learning and memory systems of intentionality and self-awareness (Cloninger et al., 2019; Zwir et al., 2020a, 2020b).

Regarding suicidal behaviour, high harm avoidance was reported as one of the most decisive factors behind suicide ideations and attempts among temperament factors (Brezo et al., 2006; Conrad et al., 2009; Mitsui et al., 2013; van Heeringen et al., 2003). Besides, lower reward-dependence (Engstrom et al., 2004; van Heeringen et al., 2003) and lower persistence (Bulik et al., 1999) may also seem to have an important effect on suicidal behaviour.

As for character components, low self-directedness (Bulik et al., 1999; Calati et al., 2008) and low cooperativeness (Calati et al., 2008) could play a role in suicidal behaviour.

Ambiguous findings are present in the case of novelty seeking and transcendence: both lower and higher scores of novelty seeking are reported among persons with a suicide attempt by several studies (Brezo et al., 2006) and despite its assumed protective effect, high transcendence was observed in individuals with a suicide attempt (Bulik et al., 1999; Conrad et al., 2009; Woo et al., 2014). Inconsistencies may stem mainly from different methodological settings – particular characteristics could be specific to the given mental disorder. For example, Eric et al. (2017) reported higher novelty seeking, higher harm avoidance, higher transcendence and lower self-directedness specific to bipolar patients with a lifetime history of a suicide attempt. On the other hand, different personality profiles can also explain contradictions in the results, since transcendence are not protective if it associates to low self-directedness and cooperativeness (Conrad et al., 2009).

7. Matter of time

The presented overview reflects a broadening knowledge about suicide: several cognitive and personality factors have been identified to have suicide-specific aspects. Although, individuals with a lifetime history of a suicide attempt were observed in the vast majority of the above cited studies, meaning that mainly trait-like characteristics were explored and operationalization of state-like alterations remained unresolved.

In general, a suicidal crisis state may arise largely due to maladaptive cognitions and poor accommodation to stressful situations, resulting in the disability to find solutions, re-evaluate present circumstances and perceive motivating factors. If a person can no longer tolerate this state, suicide attempt may occur. As it was stated earlier, little is known about the most relevant changes preceding the suicidal act. An even better understanding of the

psychological alterations featuring suicidal behaviour would be essential; even though measuring the suicidal mind prior to a suicide attempt is challenging. Capturing individuals' cognitive abilities and personality characteristics within a tight time frame following their suicide attempt seems to be a suitable solution.

Nonetheless, only a few studies have taken this aspect into consideration so far. Regarding neuropsychological functions, Deisenhammer et al. (2018) applied a maximum of 6 months as a time-frame when assessing decision-making performance, Westheide et al. (2008) measured major depressed individuals' executive functioning within 3 months following their suicide attempt, and Bartfai et al. (1990) observed problem-solving and fluency within a maximum of 22 days following patients' suicide attempt. Some authors used even tighter time-frames: Richard-Devantoy et al. (2012) measured different aspects of cognitive inhibition of elder patients within 10 days, Audenart et al. (2002) observed fluency within 7 days, and Cáceda et al. (2014) assessed executive functioning (including delay-discounting, switching, attention) within 72 hours following the participants' suicide attempt. Although not all of these studies discussed the aspect of time, they reported disturbances in most of the observed functions following a recent suicide attempt and some studies also verified that inclusion of participants as soon as possible is essential (for details see Cáceda et al., 2014)

The matter of time was taken into account also in studies focusing on personality characteristics. Lewitzka et al. (2016) compared temperament and character profiles of individuals who attempted suicide within 3 months, with those who had a suicide attempt at least 6 months ago; and demonstrated pronounced alterations among the former group even after controlling for the severity of depressive symptoms. Eric et al. (2017) measured patients with affective disorders within 72 hours following their attempt and reported differences in contrast to affective inpatients without a lifetime history of suicide attempt. They verified expressed effect of higher harm avoidance and lower self-directedness in the group of patients with major depressive disorder.

As regards impulsivity, a cross-sectional study observing individuals within 24 hours following their suicide attempt highlighted the role of certain aspects of impulsivity in suicide risk (Cole et al., 2019). Besides, a prospective study reported that some facets of impulsivity related to recent suicide attempts (Corruble et al., 2003).

Overall, there is a growing information about recent suicide attempts, but a limited amount of studies applied several days as time-frame. Therefore, knowledge about states following these acts is still limited. The present study used 72 hours as a time frame and aimed to be first to report comprehensive decision-making performance in ambiguous and risky situations following a suicide attempt.

IV. AIMS AND HYPOTHESES

Overviewing the most important observations and questions in this field, the present study aimed to explore distinct psychological characteristics of major depressed individuals with a recent suicide attempt.

The purpose of the study was to contribute to the better understanding of the suicidal mind via the following layout:

(1) Medication-free inpatients were enrolled within 72 hours following their suicide attempt, enabling to best model the suicidal crisis state preceding the attempt. Their characteristics were compared to healthy control individuals'

(2) Decision-making in ambiguous and risky situations as a cognitive component was measured. Two versions of the decision-making task were used, since the study aimed to be the first to report a comprehensive profile of this function among individuals with a suicide attempt

(3) Impulsivity, temperament and character components were observed in order to the better understanding of possible personality correlates of a recent suicide attempt during a major depressive episode

(4) Cognitive and personality characteristics best describing the mind of depressed individuals with a recent suicide attempt among the observed variables were explored

Based on the overview of the literature of this field, the following hypotheses were proposed:

(H1) Since a person who attempt suicide may experience difficulties in focusing on future plans, it was hypothesized that participants observed following a suicide attempt do not anticipate the long-term consequences of their decisions. Therefore, poor decision-making on both test versions (i.e. preference for choices with better immediate outcomes, but disadvantageous long-term results) was hypothesized

(H2) Relating to the observations of another research group examining individuals with similar inclusion criteria (Eric et al., 2017), higher harm avoidance and lower self-directedness were hypothesized to be specific to major depressive individuals' state following a suicide attempt among temperament and character factors. Regarding impulsivity, higher scores on the paper-pencil test were hypothesized in the patient group

(H3) This study included variables with presumably important role in suicidal behaviour. Thus, predictive value of some factors was hypothesized in case of major depressed individuals with a recent suicide attempt. Namely, specific role of decision-making, impulsivity and temperament and character factors was assumed

V. METHODS

1. Participants

This study was carried out at the Department of Psychiatry, Faculty of Medicine, University of Szeged. Fifty-nine individuals with a suicide attempt and a diagnosis of major depressive disorder and forty-six healthy control volunteers with no personal history of psychiatric diagnosis and suicidal behaviour were included. Participants between 18 and 65 years were recruited.

Members of the patient group were hospitalized at the clinic and were recruited and assessed within 72 hours after their suicide attempt. As it was discussed earlier, suicide attempt was defined as a "non-fatal self-directed potentially injurious behaviour with any intent to die as a result of the behaviour" (Koslow et al., 2014), and it was differentiated from other self-destructive behaviours such as self-mutilation (Jollant et al., 2005). Individuals with a suicide attempt received all necessary life-saving interventions. They were free from psychiatric medication at the time of the assessment. Tests were conducted as soon as their condition allowed it, and psychiatric treatment was started following data collection if it was necessary. All participants received the Mini-International Neuropsychiatric Interview (Sheehan et al., 1998). Patients with neurological illnesses, bipolar disorders, substance-related disorders, schizophrenia spectrum disorders, obsessive-compulsive disorders or major neurocognitive disorders were excluded. Severity of depressive symptoms was measured in the patient group by the original version of the Hamilton Depression Rating Scale (HAM-D, Hamilton, 1960).

Convenience sampling method was used during the enrolment of healthy control individuals. Their assessment took place in the outpatient exam rooms of the clinic. Patients and controls were matched for gender and age.

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Human Investigation Review Board, University of Szeged (ethical approval number: 2443). Written informed consent was obtained from each participant.

2. Measures

Besides diagnostic- and differential diagnostic assessment, severity of depressive symptoms, impulsivity, temperament and character factors and a comprehensive decision-making profile were measured in this study.

Diagnosis was checked by the Mini-International Neuropsychiatric Interview (Sheehan et al., 1998). This structured clinical interview helps to make a psychiatric diagnosis according to the ICD-10 (WHO, 2004).

Severity of depressive symptoms was measured by the original version of the Hamilton Depression Rating Scale (HAM-D, Hamilton, 1960). This is also a clinician-administered test aiming to measure the patient's depressive symptoms' severity during the last week. The test consists of 17 areas which are scored on 3 or 5-score scales (depending on the item).

Impulsivity was measured by the Barratt Impulsiveness Scale (BIS-10, Barratt, 1959). This paper-and-pencil scale consists of 34 items and has three subscales: motor impulsivity, cognitive impulsivity and non-planning impulsivity.

Temperament and character factors were assessed with the original version of the Temperament and Character Inventory (Cloninger et al., 1998). This self-reporting measure consists of 240 "true" or "false" items that measure four temperament factors (harm avoidance, novelty seeking, persistence and reward dependence), and three character dimensions (self-directedness, cooperativeness and transcendence).

Decision-making was tested by using two versions of the Iowa Gambling Task (Bechara et al., 1994; Bechara et al., 2000). All participants received standard instructions and were told that the goal of this computerized game is to win as much "virtual" money as possible. They were informed that the decks are different from each other, the game is not unfair and does not work randomly; therefore, there are better and worse choices.

In the ABCD version, four decks of cards are presented on the screen, labelled as "A", "B", "C" and "D". Each deck contains 40 cards. Participants choose cards multiple times from these decks by clicking on the top card. Following the choices, different values of gained money appears. Rewards are occasionally followed by money losses. Happy or sad faces and sounds appear together with wins and losses. The amount of rewards and the amount and frequency of losses are not randomly generated: there are advantageous and disadvantageous decks. "A" and

“B” decks are disadvantageous, associated with immediate higher rewards, but even higher future punishments; while “C” and “D” decks are advantageous long term, providing moderate immediate rewards, but also moderate losses. In the EFGH version, the layout and design is similar to the previous one, but choices are followed by immediate losses, and certain amount of money is sometimes won together with the punishment. Decks are labelled as “E”, “F”, “G” and “H”. Decks “E” and “G” are advantageous, providing high immediate punishments, but even higher future rewards, resulting in an overall gain. Decks “F” and “H” are disadvantageous, associated with lower immediate punishments, but even lower rewards.

The tasks consist of 100 trials. Each deck contains 40 cards, therefore, running out of cards from a deck is possible. For data analysis, selections were divided into five blocks (20 cards in each). Differences between the number of choices from advantageous and disadvantageous decks were compared.

3. Statistical analysis

SPSS 24 was used for data analysis (CORP IBM, 2016).

For continuous variables, the Independent-Samples T Test was used; for categorical variables, the Chi-square test was used in order to compare demographic characteristics of patients and control subjects.

One-way multivariate analysis of variance (MANOVA) with Bonferroni post-hoc analysis was conducted to reveal statistical differences on personality and cognitive variables between the two groups. Effect sizes were indicated by partial eta-squared.

Comprehensive analysis of the two groups’ performance on the IGT was made by Repeated Measures ANOVA with Bonferroni post-hoc test. The Greenhouse-Geisser correction was applied due to results of Mauchly's Test of Sphericity. A split file Repeated Measures ANOVA was conducted in order to observe the learning effect of groups during IGT blocks. Finally, since cognitive functioning could relate to years of education (Davis et al., 2008) and groups were not matched as regards this variable (see below), possible effect of it was observed via one-way multivariate analysis of covariance (MANCOVA).

Considering the issue of education level, one-way multivariate analysis of covariance (MANCOVA) was conducted in case of personality components as well with “years of education” as a covariate factor. Mediating effect of years of education could relate to impulsivity (Chamorro et al., 2012) and certain temperament and character components (Mendlowicz et al., 2000).

Pearson correlation analyses were used to reveal the interrelationship between decision-making performance, personality components and affective state measured by the HAM-D.

Binary logistic regression with a stepwise method of forward likelihood ratio was conducted to explore that among the observed variables, which are the strongest indicators of a suicide attempt during a major depressive episode and whether they can be included into a model with sufficient prediction value. Overall decision-making performance, impulsivity and temperament and character factors were set as covariates. Fitness of the model was monitored with the Hosmer-Lemeshow test.

Level of significance was set at $p<0.05$.

VI. RESULTS

1. Sociodemographic characteristics and overall between-group differences

Sociodemographic features and the results of subjects are presented in *Table 1*.

Table 1.
Demographic characteristics of participants

		Suicide attempt group (N = 59)		Healthy control group (N = 46)		Analysis		
		N	**%**	**N**	**%**	χ^2	***df***	***p***
Gender	**Male**	18	35.5	20	43.5	1.883	1	0.170
	Female	41	69.5	26	56.5			
		Mean	**SD**	**Mean**	**SD**	***t***	***df***	***p***
Age (years)		35.73	12.25	34.24	10.98	0.646	103	0.519
Education (years)		11.12	2.10	12.98	2.44	-4.187	103	<0.001

Individuals with a recent suicide attempt and healthy subjects did not differ in terms of gender ratio ($\chi^2(1) = 1.883$, $p = 0.170$) and age ($t(103) = 0.646$, $p = 0.519$), but they statistically differed in terms of education level ($t(103) = -4.187$, $p < 0.001$).

There was a significant difference between the two groups on the combined effect of decision-making, impulsivity, temperament and character factors (Pillai's trace = 0.530; $F(10,88) = 0.530$, $p < 0.001$, $\eta p^2 = 0.53$).

The following sections will detail these differences and present variables with the strongest statistical power.

2. Comprehensive analysis of decision-making

Participants mean score was - 1.94 (SD = 3.84) in the IGT ABCD and 16.82 (SD = 4.57) in the IGT EFGH. Regarding healthy control participants, IGT ABCD mean score was 20.27 (SD = 4.20) and IGT EFGH mean score was 32.37 (SD = 5.00). The Repeated Measures ANOVA revealed significant interaction effect between factors BLOCKS and GROUPS on the IGT ABCD ($F(3.357, 345.812) = 4.171$, $p = 0.005$, $\eta p^2 = 0.04$). A trend towards significant differences was shown on the IGT EFGH ($F(3.078, 317.017) = 2.370$, $p = 0.069$, $\eta p^2 = 0.02$).

Bonferroni post hoc analyses revealed significant between-group differences in block 2 ($F(3.357, 345.812) = 4.171$, $p = 0.04$, $\eta p^2 = 0.04$), block 3 ($F(3.357, 345.812) = 4.171$, $p < 0.001$, $\eta p^2 = 0.04$), block 4 ($F(3.357, 345.812) = 4.171$, $p < 0.001$, $\eta p^2 = 0.04$) and block 5 ($F(3.357, 345.812) = 4.171$, $p = 0.008$, $\eta p^2 = 0.04$) during the IGT ABCD; and block 2 ($F(3.078, 317.017) = 2.370$, $p = 0.007$, $\eta p^2 = 0.02$) and block 3 ($F(3.078, 317.017) = 2.370$, $p = 0.013$, $\eta p^2 = 0.02$) during the IGT EFGH (*Figure 1)*.

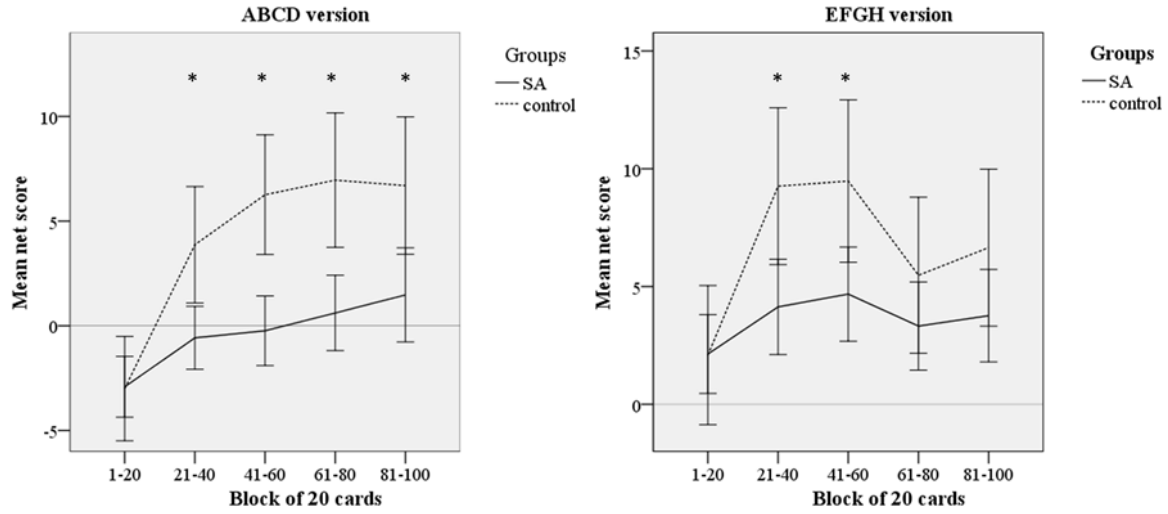

Figure 1.

Changes in decision-making performance of 59 patients with a suicide attempt (SA) and 46 healthy control subjects (control) during the five blocks of two versions of the Iowa Gambling Task. Mean net scores (disadvantageous minus advantageous choices) and standard error means are shown. The * symbol indicate statistical differences ($p < 0.05$).

The Bonferroni post hoc test revealed the following within-group differences. During the IGT ABCD, the block-to-block differences were not significant in the patient group. However, there was a significant difference between block 1 - block 5 ($F(3.357, 345.812) = 19.146$, $p = 0.045$, $\eta p^2 = 0.16$). In the control group, block 1 differed significantly from the other blocks ($F(3.357, 345.812) = 19.146$, $p < 0.001$, $\eta p^2 = 0.156$in each pairings). Block-to-block differences were present only between block 1 and block 2 ($F(3.357, 345.812) = 19.146$, $p < 0.001$, $\eta p^2 = 0.16$).

During the IGT EFGH, depressed suicidal participants' performance was constant statistically. Control subjects' performance differed significantly between block 1 - block 2 ($F(3.078, 317.017) = 8.482$, $p < 0.001$, $\eta p^2 = 0.08$) and block 3 - block 4 ($F(3.078, 317.017) = 8.482$, $p = 0.38$, $\eta p^2 = 0.08$). Their performance in block 1 differed from block 2 ($F(3.078, 317.017) = 8.482$, $p < 0.001$, $\eta p^2 = 0.08$), block 3 ($F(3.078, 317.017) = 8.482$, $p < 0.001$, $\eta p^2 = 0.08$), but did not differ significantly from block 4 ($F(3.078, 317.017) = 8.482$, $p = 0.737$, $\eta p^2 = 0.08$) and block 5 ($F(3.078, 317.017) = 8.482$, $p = 0.079$, $\eta p^2 = 0.08$). As learning tendencies can be followed up until block 4 in the healthy comparison group, a Repeated Measures ANOVA was conducted during the first three blocks of the IGT EFGH, which revealed a significant interaction between factors BLOCKS and GROUPS ($F(1.609, 165.735) = 5.638$, $p = 0.008$, $\eta p^2 = 0.05$).

Since the two groups were not matched for education, a Repeated Measures ANCOVA was conducted with "years of education" as the covariate. The covariate had a significant effect on performance during the ABCD version ($F(3.444, 351.319) = 4.791$, $p = 0.002$, $\eta p^2 = 0.05$); while it could not be observed during the EFGH ($F(3.077, 313.859) = 0.561$, $p = 0.647$, $\eta p^2 < 0.01$). The interaction between BLOCKS and GROUPS ($F(3.444, 351.319) = 1.644$, $p = 0.172$, $\eta p^2 = 0.02$) was no longer significant on the IGT ABCD after controlling for "years of education". However, the post hoc test still showed a trend towards between-group differences in block 2 ($F(3.444, 351.319) = 1.644$, $p = 0.063$, $\eta p^2 = 0.02$), and significant differences in block 3 $F(3.444, 351.319) = 1.644$, $p = 0.003$, $\eta p^2 = 0.02$) and block 4 ($F(3.444, 351.319) = 1.644$, $p = 0.006$, $\eta p^2 = 0.02$).

As regards HAM-D was not assessed among healthy control individuals, it was essential to observe its possible correlations with patients' test results. Patients scored an average of 17.754 points (SD = 6.384) on HAM-D. However, there was no significant correlation between

IGT tasks and HAM-D scores (ABCD: r(55) = -0.144, p = 0.286; EFGH: r(55) = 0.073, p = 0.591).

3. Personality differences

Between-subject personality differences are presented in *Table 2*. Significant between-group differences were found regarding impulsivity, harm avoidance, self-directedness, cooperativeness and transcendence.

Table 2.

Personality differences between individuals with a diagnosis of major depressive disorder and a recent suicide attempt (SA) and healthy controls (HC)

	SA (N=59)	**HC (N=45)**	**Post-hoc test**			
	Mean (SD)	Mean (SD)	*F*	*df*	*p*	ηp^2
BIS/Total	71.54 (12.71)	61.31 (9.78)	19.51	1	<0.001	0.17
TCI/NS	18.52 (6.00)	20.2 (5.71)	2.02	1	0.159	0.02
TCI/HA	21.91 (7.00)	12.49 (5.90)	51.12	1	<0.001	0.35
TCI/RD	15.41 (3.08)	16.29 (3.00)	2.06	1	0.154	0.02
TCI/P	4.74 (2.51)	4.71 (1.83)	0.04	1	0.948	<0.01
TCI/S-D	23.63 (6.14)	31.13 (4.04)	49.29	1	<0.001	0.34
TCI/C	28.06 (6.60)	31.13 (4.04)	7.01	1	0.009	0.07
TCI/T	15.35 (6.97)	11.22 (5.35)	10.59	1	0.002	0.10

Abbreviations: BIS (Barratt Impulsiveness Scale), TCI (Temperament and Character Inventory), NS (novelty seeking), HA (harm avoidance), RD (reward dependence), P (persistence), S-D (self-directedness), C (cooperativeness), T (transcendence)

Years of education was not affect significantly the combined effect of the observed factors (Pillai's trace = 0.454; F(8,89) = 9.232, $p < 0.001$, $\eta p^2 = 0.45$). Between-group differences remained intact as regards impulsivity (F(1) = 12.905, $p = 0.001$, $\eta p^2 = 0.12$, harm avoidance (F(1) = 43.470, $p < 0.001$, $\eta p^2 = 0.31$, self-directedness (F(1) = 41.175, $p < 0.001$, $\eta p^2 = 0.03$ and transcendence (F(1) = 6.548, $p = 0.012$, $\eta p^2 = 0.06$. However, groups were not differed concerning cooperativeness when considering years of education as a covariate (F(1) = 2.437, $p = 0.122$, $\eta p^2 = 0.03$).

As regards the interrelationship between personality variables and depressive symptom severity, significant, but weak correlations were revealed between HAM-D scores and harm avoidance (r(52) = 0.390, $p = 0.004$), and HAM-D scores and impulsivity (r(55) = 0.372, $p = 0.004$). There was no significant correlations between other personality characteristics and HAM-D results (novelty seeking: r(52) = -0.087, $p = 0.534$; reward dependence: r(52) = -0.133, $p = 0.337$; persistence: r(52) = 0.118, $p = 0.396$; transcendence: r(52) = 0.067, $p = 0.632$; cooperativeness: r(52) = -0.160, $p = 0.251$; self-directedness: r(52) = -0.191, $p = 0.167$).

4. Model

Stepwise forward binary logistic regression model included IGT ABCD net score, harm avoidance and self-directedness in the equation from the observed components presented in *Table 2*. These variables added significantly to the prediction: IGT ABCD net score ($\chi^2 = 7.459$; df: 1; $p = 0.006$), harm avoidance ($\chi^2 = 7.502$; df: 1; $p = 0.006$), and self-directedness ($\chi^2 = 6.763$: 0.169; df: 1; $p = 0.009$). No indication of multicollinearity was found among these variables (VIF below 2.247 for every variable in the model). The baseline model ($\chi^2 = 0.816$; df: 1; $p = 0.366$) had an accuracy of 54.5% overall percentage. The Hosmer–Lemeshow test (χ^2: 9.262; df: 8; $p = 0.321$) indicates that this model adequately fitted the data. The model was significant (χ^2: 58.108; df: 5; $p < 0.001$), explains 59.4% of the variance (Nagelkerke R^2) and correctly classified 79.8% of cases.

VII. DISCUSSION

This study observed significant decision-making, impulsivity, temperament (i.e. harm avoidance) and character (i.e. self-directedness, cooperativeness, transcendence) differences between medication-free major depressed individuals with a recent suicide attempt and healthy control participants. Besides, it performed a comprehensive analysis of decision-making functioning. Lastly, it presented a model indicating that among these variables, poor decision-making on the IGT ABCD, high harm avoidance and low self-directedness were the most powerful characteristics of the patient group. These three factors had a significant predictive value and classify 79.8% of participants correctly.

Therefore, the main hypotheses were confirmed by the results, while some minor assumptions were not verified.

(H1) The first hypothesis concerning decision-making performance on both IGT versions was supported by the results: significant between-group differences (i.e. poor performance of the patient group) were present during the ABCD version, and a trend towards significant alterations during the EFGH version could also be reported

(H2) Findings verified the assumed between-group personality differences: the patient group could be characterized by higher harm avoidance, lower self-directedness and higher impulsivity. However, some further between-group differences were also revealed. Lower cooperativeness and higher transcendence could be observed among major depressed individuals with a recent suicide attempt

(H3) Predictive value of decision-making performance, impulsivity and temperament and character factors was assumed. The study verified the role of decision-making during the IGT ABCD, harm avoidance (as a temperament factor) and self-directedness (as a character factor). Thus, impulsivity and IGT EFGH were not included in the model

1. Decision-making

As regards decision-making, significant between-group differences during IGT ABCD and a trend towards significant alterations during IGT EFGH was revealed. Effect of IGT ABCD was dominant, since it was included in the model presented.

Detailed analysis of within-group and between-group performance during the IGT blocks revealed some instructive findings. Analysis of within-group performance of major depressive individuals with a recent suicide attempt showed an almost completely constant performance at different stages of the IGT ABCD and EFGH: significant improvement could only be seen between block 1 and block 5 on the IGT ABCD. In contrast, results of the control individuals increased significantly after the first block of both versions. It is an important difference, since at the beginning of the game, participants should get familiar with the rules; therefore, decision-making performance in risky situations can be observed in the second part of the task (Brand et al., 2007). Significant improvement following the first block may indicate that control subjects identified advantageous decks quickly and they preferred them; while in the case of patients, learning tendencies could not be detected.

It is important to notice, that a significant drop in control participants' performance could be seen following block 3 of the IGT EFGH. Their poorer performance in the last two blocks can be explained by the quick identification of the advantageous strategy, causing the running out of cards from the beneficial decks (Davis et al., 2008). Counterbalancing of the order of the IGT versions was not implemented in this study: learning effect following the IGT ABCD could not be controlled. General rules of the IGT were already known at the beginning of the IGT EFGH; thereby, sooner identification of advantageous decks could be present, which can explain the running out of advantageous cards in case of the control subjects. Nevertheless, their worsened performance in block 4 moderated the adequate comparison of the groups. Hence, it should be highlighted that statistical analysis of the first 3 blocks revealed significantly differences between the IGT EFGH performance of the groups.

Anyhow, patients' decision-making can be regarded as disadvantageous on both versions of the IGT. Findings are in line with previous studies reporting deficient decision-making performance of depressed suicide attempters on the IGT ABCD (Jollant et al., 2005; Oldershaw et al., 2009; Westheide et al., 2008). To the best of our knowledge, suicide

attempters' performance on the IGT EFGH was not assessed before; thus, this is the first study providing information about the comprehensive IGT profile of this group.

Without the IGT EFGH, results of individuals with a recent suicide attempt could be explained by increased reward-sensitivity or decreased punishment-sensitivity. Results of the EFGH showed opposite tendencies; therefore, it questioned the applicability of reward- and punishment-based models in this group. Accordingly, the additional information of the IGT EFGH allows to more precisely explain how the reported decision-making pattern may relate to the status of major depressive individuals following a suicide attempt.

Patients preferred decks with the best immediate outcomes, causing poor performance on both IGT versions. Bechara et al. (2000) explained such a decision-making profile in the case of patients with OFC / VMPFC lesion by myopia for future consequences. However, it should be clarified whether individuals with a recent suicide attempt do not care for the future for psychological reasons, or if they cannot plan for it because of other contributing neuropsychological dysfunctions. Prediction of the near future is based on learning models of action-dependent outcomes and may require several cognitive skills.

Consequently, more functions were reported to be essential for proper IGT performance including working memory, which holds information long enough for attention, evaluation and reasoning strategies (Bechara et al., 1994), and cognitive inhibition, which allows participants to reject choices seeming to be immediately advantageous (Bechara et al., 2000). Differentiation of risky and safe choices due to immediate and long-term value-attribution is also important (Jollant et al., 2010), and includes several functions. For instance, it presumes processes associate to the DLPFC, which provides future reward predictions (van Heeringen et al., 2011), the computation of subjective value mediated by the amygdala and striatum (Phelps et al., 2014), and learning from reinforcement besides the functions moderated by the OFC / VMPFC (Jollant et al., 2010; Phelps et al., 2014). Although the role of executive functions and explicit understanding in decision-making was reported by Ochoa et al. (2013), others found that decision-making performance is independent from other cognitive processes, for example from executive functions measured by the Wisconsin Card Sorting Task (Must et al., 2006) or cognitive control functions and attention (Hoehne et al., 2015; Richard-Devantoy et al., 2013). Furthermore, explicit understanding was not reported as a sufficient condition for advantageous decision-making in suicide attempters (Jollant et al., 2013), which points out that other

processes, like implicit bodily signals, known as somatic markers, should also be taken into account (Bechara et al., 1994; Jollant et al., 2013). In summary, results of the IGT tasks revealed that major depressive individuals with a recent suicide attempt made their decisions by considering factors relevant in the short-term, which could be explained partly by cognitive deficits and also by psychological factors.

As regard as cognitive abilities may mediate the IGT performance and groups were not matched for education level, it is important to discuss the possible effect of this factor. According to the statistical analysis, years of education had a significant effect on learning tendencies during the IGT ABCD and it reduced between-group differences as a covariate factor. Education level was reported to have a significant effect on the IGT performance also by Davis et al. (2008). Higher educational level may affect rational decision-making through the higher acquired knowledge (Davis et al., 2008). However, lower levels of education could be a relevant risk factor for lifetime major depressive disorder (Kessler et al., 2003) and it was reported as the highest risk factor for suicidal behaviour among individuals with suicidal thoughts (Choi et al., 2017). Therefore, findings of this study may represent the depressed suicidal group's characteristics and may reflect to the interrelation between poorer cognitive abilities and suicidal behaviour.

The fact that IGT ABCD was one of the strongest characteristics of major depressed individuals fits well to the findings of previous research. Accordingly, meta-analyses confirmed moderate effect size of decision-making on suicidal behaviour (Perrain et al., 2021; Richard-Devantoy et al., 2014). However, effect size was more emphasized when patients with a lifetime history of a suicide attempt were compared to healthy controls or when individuals choosing a violent method and patient controls with no suicidal history were enrolled (Perrain et al., 2021). The fact that IGT EFGH was not included in the model can be explained by the absence of counterbalancing of IGT versions, since the logic of the test was not unknown for participants. As it was discussed earlier, this circumstance could seemingly moderate between-group differences.

2. Personality correlates

In case of personality components, higher harm avoidance, lower self-directedness, lower cooperativeness, higher transcendence and higher impulsivity were observed among depressed individuals with a recent suicide attempt in comparison to control subjects. However, the prediction model included only harm avoidance and self-directedness from these components, indicating that their role could be more pronounced.

In terms of suicidal behaviour, impulsivity could play an important role in the transition of suicidal ideations into attempt (Klonsky et al., 2016) and could interact with depressive state and hopelessness (Swann et al., 2008). Impulsivity was indeed proved to be a possible characteristic of depressive state and an important indicator of suicide risk among different groups of individuals: distinct aspects of impulsivity could differentiate persons with mental disorders from healthy controls (Ponsoni et al., 2018), depressive states from manic states (Swann et al., 2008), and differ among patients with or without a lifetime history of a suicide attempt (Corruble et al., 2003; Ponsoni et al., 2018). Besides, certain facets could be sensitive for suicide ideation or intent (Cole et al., 2019; Klonsky et al., 2016; Pompili, 2008). Thus, findings are in line with previous research and interrelation of impulsivity and depressive symptom severity could also be explained. On the other hand, contrary to the hypothesis, impulsivity was not entered in the model presented.

Different groups of individuals were enrolled in the above mentioned studies and distinct methodological concepts were applied. Besides, these papers highlighted mainly between-group differences regarding impulsivity and therefore gave moderate information about its statistical power. A meta-analysis revealed small effect size of impulsivity on suicidal behaviour (Anestis et al., 2014); therefore, less robust power of this factor in the model also corresponds to previous findings. It could be challenging to explore the role of impulsivity on suicidal behaviour with paper-pencil tests – its behavioural indicators may represent a more relevant predictive power.

Concerning temperament and character factors, a fearful, pessimistic temperament style (higher harm avoidance) and characteristics of aimlessness, blaming (lower self-directedness), hostility, self-centeredness (lower cooperativeness), altruism and spirituality (higher transcendence) can be highlighted among depressed individuals with a recent suicide attempt.

These results are in line with previous findings: higher harm avoidance (Brezo et al., 2006; Bulik et al., 1999; Calati et al., 2008; Conrad et al., 2009; Ekinci et al., 2012; Hur & Kim, 2009; Mitsui et al., 2013; Eric et al., 2017), lower self-directedness (Bulik et al., 1999; Calati et al., 2008; Conrad et al., 2009; Hur & Kim, 2009; Eric et al., 2017) and lower cooperativeness (Calati et al., 2008; Hur & Kim, 2009) were identified as relevant factors of suicidal behaviour consequently.

Higher transcendence could be an unexpected finding at first glance; since it can be regarded as an adaptive characteristic. Interestingly, its role in suicidal behaviour was proved by several other studies as well (Bulik et al., 1999; Conrad et al., 2009; Woo et al., 2014). Higher transcendence per se might have a protective effect, but it can also have negative aspects if associated with other non-adaptive character factors. The constellation of higher transcendence, lower self-directedness and lower cooperativeness could indicate schizotypal features, psychosis-proneness and / or depression (Bulik et al., 1999; Cloninger et al., 1998). This study revealed this non-adaptive character constellation; thus, higher transcendence's negative aspects should be highlighted – for example illogical, immature, suspicious behaviour of individuals (Woo et al., 2014).

As regards cooperativeness, it was no longer differentiate the groups when controlling for years of education. The effect of education level on certain personality factors was reported earlier: although most results related to its relationship with novelty seeking (Mendlowicz et al., 2000), its impact on cooperativeness was also observed (Al-Halabí et al., 2010).

Considering that the present model included harm avoidance and self-directedness and interpretation of personality components in constellations could be essential, examination of possible interactions between these factors should be discussed. Low harm avoidance and high self-directedness relate to resilience, the ability to maintain a healthy mental state in stressful situations (Kim et al., 2013). The model shows an inverse personality constellation, indicating that adaption to different life-challenges is affected in this sample. Some authors suggest that higher harm avoidance and lower self-directedness may be specific to depressive states per se (Calati et al., 2008; Eric et al., 2017; Spittlehouse et al., 2010; Zaninotto et al., 2016); although, Conrad et al. (2009) reported that effect of these alterations can be heightened in suicidal behaviour.

It is important to note that harm avoidance was not independent from depressive symptom severity in this research, but correlation between self-directedness and depressive symptoms were not identified. Temperament factors are commonly mentioned as trait-like phenomena, but they can also interact with the individuals' current states. Accordingly, previous studies also indicated that severity of depressive symptoms could interact with harm avoidance (Abrams et al., 2004; Hruby et al., 2009; Spittlehouse et al., 2010). In summary, higher harm avoidance can be observed depression per se; however, it has a more pronounced effect in case of suicidal behaviour (Conrad et al., 2009; van Heeringen, 2003).

Finally, since relevance of a maladaptive personality constellation was found, possibility of comorbid personality disorders among participants should be raised. Accordingly, a link between certain personality disorders (e.g. borderline personality disorder) and personality features such as lower self-directedness (Conrad et al., 2009) and impulsivity (Giegling et al., 2009) was verified in previous studies. Besides, their comorbidity with major depressive disorder and suicidal behaviour is also well-documented (DSM-5). However, data relating to this diagnostic category was not collected and therefore, this issue remained unclear in this study.

3. General discussion

This study focused on some possibly relevant cognitive and personality factors and observed their impact on major depressive individuals' status following a recent suicide attempt. Overall, the results suggest that I) the inability to make decisions according to the assessment of possible future consequences (poor decision-making performance), II) a pessimistic and shy temperament (higher harm avoidance), and III) loss of willpower and goal-orientation (lower self-directedness) were the strongest characteristics of the patients.

Despite this study examined only some particular components, the model could grasp dynamics similar to those exposed by prominent theories of suicidal crisis. Accordingly, individuals in this state may feel themselves to be dislikeable, incompetent, guilty (Baumeister, 1990), socially anxious, helpless and hopeless (van Heeringen, 2003). The desire to escape from these negative circumstances immediately often results in self-destructive behaviour, revealing a short-term focus of this persons (Baumeister, 1990).

Although the results are mixed and non-exclusive, neural networks with serotonergic modulation seem to play an important role in these two personality factors (Giegling et al., 2009; Peirson et al., 1999; Van Heeringen & Marusic, 2003) and in decision-making (Jollant et al., 2005), raising the possibility that changes in the serotonergic system may affect these components and link them. Besides, the OFC can be highlighted as an important structure connecting both to harm avoidance (Kyeong et al., 2014; Westlye et al., 2011) and to decision-making functioning (Jollant et al., 2005) – including functional changes during decision-making in ambiguous and risky situations (Jollant et al., 2010).

These findings present the status of major depressed patients within 72 hours following their suicide attempt. It should be discussed whether these alterations can be regarded as trait-like factors or state-like phenomena that characterise depressed individuals' mind following their attempt. Although, since design of this research does not to allow to observe this issue directly, it is important to consider previous research in this field.

As for poor performance on the IGT, there is no consensus on whether this is a trait- or state-dependent factor. Some studies support the former hypothesis (Hoehne et al., 2015; Jollant et al., 2005), while limited information is available relating the latter one, since this was the first study to observe IGT performance of individuals following a recent suicide attempt. Our preliminary data on depressed patients with a lifetime history of a suicide attempt (Hegedűs et al., 2015) may add to the interpretation of this issue. This patient group showed significantly poorer performance on the IGT ABCD than healthy subjects, but the two groups' performance did not differ significantly on the IGT EFGH. Interestingly, Must et al. (2006) reported similar performance of major depressed individuals without a history of a suicide attempt. Although comprehension of these results should be considered with caution, it is important to highlight that major depressive individuals with a recent suicide attempt shew a different decision-making profile. Their preference for disadvantageous decks on both versions may indicate more pronounced decision-making alterations, which may represent a characteristic of the depressed suicidal mind. Hence, an alternative viewpoint is also possible: these individuals could have poorer decision-making as a trait-like alteration, which deficit could become more pronounced when suicidal thoughts and intent occur, resulting in state-like alterations as well.

Concerning harm avoidance, temperament factors are commonly referred as relatively stable phenomena, but it should be highlighted that they can also interact with the individuals'

current states as it was discussed earlier. As regards lower self-directedness, its state-like alterations specific to suicidal behaviour can also be observed: it differentiates major depressed individuals with suicidal ideations from non-ideators (Conrad et al., 2009). Even if these factors can be regarded as vulnerability components of suicidal behaviour by some previous studies, their pronounced changes may be specific to suicidal crisis states as well, showing the importance of the time of the assessment.

Measuring the state preceding a suicide attempt is challenging – observing the period following this act could best model the suicidal mind. Although, it is important to note that relevant changes may occur following a suicide attempt, which moderate the status of these individuals. For instance, a growing intent to live, reframing of personal purposes and resolving of interpersonal conflicts can be present (Cáceda et al., 2014). This phenomenon is often referred as a cathartic effect, which could indeed result in the short-term improvement of the symptoms of depressive state (Rihmer & Rutz, 2009; van Praag & Plutchik, 1985). In the light of these, the question may arise, whether observations of this study could reflect the major depressed individuals state affected by the suicidal crisis. Since most patients shew moderate to severe depressive symptoms, considerable improvement cannot be assumed. Furthermore, Cáceda et al. (2014) reported the decrease in depressive symptoms, hopelessness and suicidal ideation after 1 week, while individuals could be characterized by severe symptoms within 72 hours following their suicide attempt.

Studies related to suicidal behaviour can contribute to the better understanding of this phenomenon – and thus, to the improvement of methods for suicide-prevention. Heterogeneous prevention programs are available, of which impact of particular strategies can be highlighted, such as the improvement of distinct treatment possibilities for mental disorders, restriction of access to lethal means, school-based mental health and suicide-awareness programmes (Zalsman et al., 2016). Different suicide prevention strategies could target whole populations, groups with higher risk for suicide or individuals with suicide-susceptibility (Large, 2018).

The present study enrolled psychiatric inpatients with major depressive disorder; hence, its results could contribute mainly to developing group- or individual-level strategies in the future. Although most suicides are completed by people who have never been in psychiatry, it is important to highlight that individuals with a past, recent or current psychiatric hospitalization

have a higher risk for suicide: for example, patients within 3 months after discharge have a 100-fold risk for it (Large, 2018). Thus, assessment of psychiatric inpatients is important.

Moreover, measuring individuals following a suicide attempt could broaden the possibilities of detecting suicidal crisis state. Currently, knowledge about suicide proneness is pronounced, while only a limited number of tools are available to reveal acute risk for suicide. With the identification of neuropsychological and personality factors specific to suicidal crisis, compilation of less explicit, objective test batteries could be possible. These batteries can contribute to more established decisions about time of discharge or to identifying patients who need a stricter follow-up.

It can be seen that this thesis highlighted certain psychological factors, which can mediate suicidal behaviour and can be detected by the psychiatric care system. Although psychological risk factors are not exclusive, these variables are measurable and most of them can be affected via different ways.

As an outlook, it should be highlighted that the thesis was written during the COVID-19 pandemic era – which raises some concerns regarding mental health among other issues. This disease affects several biological, psychological and social factors related to suicidal behaviour: it could increase the vulnerability for suicide via its direct effects on the central nervous system and its indirect effects, for instance social isolation, rise of unemployment (Conejero et al., 2021), increasing anxiety and depressive symptoms (Osváth, 2021). Although a decrease in suicides could be observed in the first period of the pandemic (probably due to the well-known “pulling-together” effect of crises), an increase in suicide attempts were reported following the first months (Tanaka & Okamoto, 2021). Studies exploring the link between COVID-19 pandemic and suicidal behaviour, and planning of prevention-programs seems to be urgent. These will presumably determine suicide-related studies in the near future.

To summarize the importance of this study, it observed cognitive and personality characteristics of major depressed individuals in quite a sensitive state: within 72 hours following their suicide attempt. It was the first to report comprehensive decision-making profile measured by the IGT of persons with a suicide attempt. It is important to highlight that participants were free from psychiatric medication at time of the assessment, which strengthen the results of this study. Psychiatric medication, especially benzodiazepines, could have long-, and short-term effects on cognitive functioning (Buffett-Jerrott & Stewart, 2002); and on

personality components such as temperament and character factors (Conrad et al., 2009; Hruby et al., 2009; Schneider et al., 2015) and impulsivity (Peluso et al., 2007). Although, most studies observed the effect of pharmacological treatment on behavioural aspects of impulsivity (for review see Moeller et al., 2001).

This study has limitations, of which the lack of depressed control groups with a past suicide attempt and without a history of a suicide attempt is the most relevant, because it narrows the possibility of a suicidal state-specific interpretation. A within-group design could also give data about state-dependent changes; however, the applied decision-making task is not repeatable. Information about type of suicide attempts (violent or non-violent), history of previous attempts, ongoing suicide intent / ideation and comorbid personality disorders was not collected; although, these variables could mediate the findings. Besides, participants were not matched for education. Finally, a limitation specific to the assessment of decision-making was also arisen: administration of the two versions of the IGT was not counterbalanced, which causes some methodological concerns.

In summary, further studies should explore other psychological dimensions possibly specific to suicidal crisis. In addition, recruitment of depressive persons with past history of a suicide attempt and with no history of a suicide attempt as control participants or a within-subject study design may also add to the existing research.

VIII. CONCLUSIONS

This thesis presented the status of medication-free individuals with major depressive disorder within 72 hours following their suicide attempt, and revealed relevant alterations relating to decision-making in ambiguous and risky situations, personality aspects of impulsivity, and temperament and character components of harm avoidance, self-directedness, cooperativeness and transcendence. Although, effect of decision-making, harm avoidance and self-directedness were pronounced. These three variables represent a segment of the experiences relating to suicidal crisis during a major depressive episode: the individuals' difficulties in making decisions according to the assessment of possible future consequences, pessimistic, shy temperament and loss of willpower and goal-orientation.

To portray the observations of the study, Ágnes Kántor created a touching illustration *(Figure 2.)*.

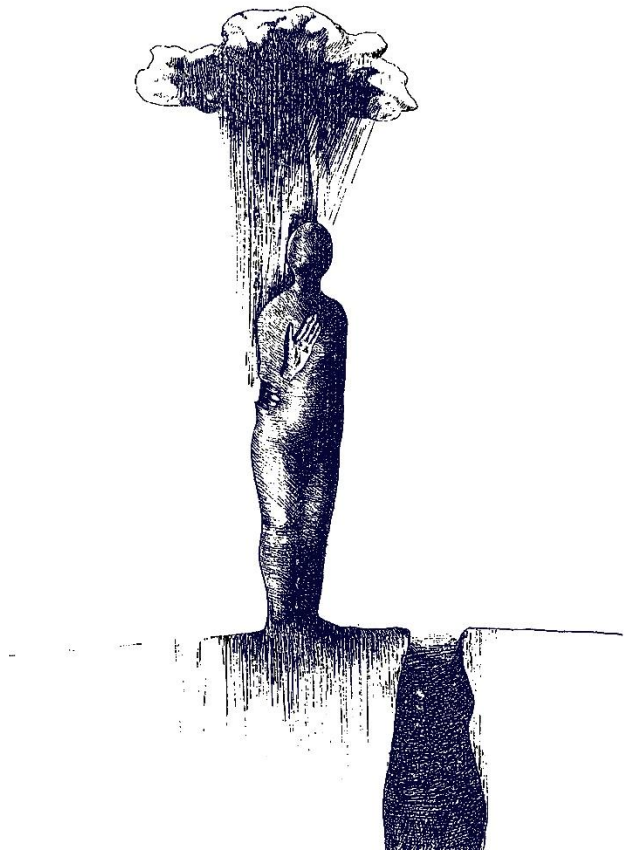

Figure 2. Illustration by Ágnes Kántor (2020)

I am grateful for the opportunity to finish the thesis with such a wonderful piece of art – which helps me to summarize my thoughts about the present study. I consider that the phenomena highlighted in the model grasp the feelings to be trapped and give an insight into a period, when non-existence is regarded as a possibility. Hence, besides the practical importance of this study, I believe that its significance also lies in that it contributes to a better understanding of the state in which individuals attempt suicide. Therefore, it could deepen the professionals' empathy towards patients. It certainly affected my attitude and encouraged me to treat them in consideration of these aspects.

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Research paper

Decision-making performance of depressed patients within 72 h following a suicide attempt

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ABSTRACT

Background: The significance of decision-making in suicidal behaviour is often highlighted; however, the performance of persons in suicide crisis is unknown. This study aimed to explore the comprehensive decision-making profile of depressed patients following a suicide attempt.

Methods: Decision-making was measured by reward- ("ABCD") and punishment- ("EFGH") sensitive versions of the Iowa Gambling Task (IGT) in 59 medication-free depressed patients within 72 h after a suicide attempt and in 46 healthy control subjects. Severity of depressive symptoms was assessed in the patient group by the Hamilton Depression Rating Scale.

Results: Performance of the two groups differed significantly on the IGT ABCD, while a trend towards significant differences was seen on the IGT EFGH. Severity of depressive symptoms did not affect the depressed participants' decision-making performance.

Limitations: Subjects were not matched for years of education. Administration of the IGT ABCD and IGT EFGH was not counterbalanced. Methods of suicide attempts and history of previous attempts were not collected.

Conclusions: Individuals with a recent suicide attempt showed decision-making dysfunction on both IGT versions. However, on the EFGH, the overall difference between groups was not significant, depressed participants' performance remained poor during all blocks. Their behaviour reflected a focus on best immediate possible outcomes, not regarding future adverse consequences. This could be a result of psychological and cognitive alterations which modulate suicidal behaviour independent from mood. Further longitudinal studies should verify this possibility. Investigation of state-dependent neuropsychological characteristics of suicidal behaviour might be essential for detecting acute suicidal crisis.

1. Introduction

A suicide attempt, which occurs in a complex bio-psycho-social context, is preceded by a specific state, a suicidal crisis, in which thoughts drift towards the intent to die. Cognitive processes determine how a person perceives and evaluates information and how she or he reacts to external and internal stimuli; therefore, the significance of neuropsychological factors in suicide is often highlighted. Deficits in cognitive inhibition (Richard-Devantoy et al., 2012), cognitive flexibility (Keilp et al., 2001), fluency (Audenaert et al., 2002; Keilp et al., 2001), attention (Keilp et al., 2001, 2013), and in higher-order cognitive processes, for instance problem-solving (Pollock and Williams, 2004) and decision-making (Jollant et al., 2005) in suicidal patients have been reported so far. These impairments lead to a distorted thinking style and a helpless, hopeless feeling as a consequence of ineffectiveness in recognition of personal and social resources (van Heeringen and Marusic, 2003). In summary, a suicidal crisis state may arise largely due to these maladaptive cognitions and intense psychological pain. If a person can no longer tolerate this state, she or he may engage in a suicide attempt (Wenzel and Beck, 2008). Therefore, an even better understanding of the neuropsychological alterations featuring suicidal behaviour would be essential; however, measuring the suicidal mind prior to a suicide attempt is challenging. Capturing suicidal persons' cognitive abilities within a tight time frame following their attempt seems to be a suitable solution. Since decision-making is one of the most important cognitive factors for suicidal behaviour, this study aimed to measure this function in depressed patients after a suicide attempt.

Decision-making refers to a process resulting in choices in various situations when more options are available. The specificity of this dysfunction in suicidal behaviour was first reported by Jollant et al. (2005), who found that suicide attempters choosing violent methods underperformed in a decision-making task compared to non-suicidal subjects with affective disorders and healthy controls. A

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possible role of decision-making was originally hypothesized due to serotonergic impairments in the orbitofrontal cortex (OFC)/ventromedial prefrontal cortex (VMPFC) in suicidal individuals (Jollant et al., 2005), since these areas play an important role in decision-making (Bechara et al., 1994). It should be mentioned, that OFC and VMPFC are partially overlapping, densely interconnected areas, which are responsible for similar functions; therefore, clear differentiation of them could be difficult in clinical studies (Zald and Andreotti, 2010; Pujara and Koenigs, 2014). Hence, they are referred as OFC/VMPFC in this paper. Though the OFC/VMPFC were highlighted to be responsible for decision-making, it is necessary to note that complexity of this function indicates an extended neural circuit, which includes the dorsolateral prefrontal cortex (DLPFC), amygdala, striatum (Clark et al., 2004; Naqvi et al., 2006; Pujara and Koenigs, 2014), brainstem and insula (Naqvi et al., 2006; Phelps et al., 2014).

Besides Jollant et al. (2005), several further studies measuring different suicidal subgroups and using different decision-making tasks confirmed that decision-making has an important role in suicidal behaviour (Westheide et al., 2008; Malloy-Diniz et al., 2009; Oldershaw et al., 2009; Clark et al., 2011; Bridge et al., 2012; Deisenhammer et al., 2018). A meta-analysis supported the association between suicidal behaviour and poor decision-making performance in unipolar and bipolar patients as well (Richard-Devantoy et al., 2015). Furthermore, decision-making deficit was found in healthy first-degree relatives of suicide completers compared to healthy and depressed control subjects with no familial history of a suicide attempt, suggesting that this impairment may be a cognitive endophenotype of suicidal behaviour (Hoehne et al., 2015). However, Gorlyn et al. (2013) highlighted that the majority of these studies reported decision-making deficit in specific suicidal subgroups (i.e. violent attempters or past attempters with current suicidal ideation), i.e. not in all suicidal individuals; therefore, it cannot be a global marker for suicidal behaviour.

According to the classification of Phelps et al. (2014), different tasks capture different aspects of decision-making. One of the most often used decision-making tests is the Iowa Gambling Task (IGT, Bechara et al. 1994), which was developed to simulate real-world decision-making processes in ambiguous and risky situations. During this computerized card game, participants can choose cards from four decks, which are followed by different amount of immediate rewards and sometimes also by money losses. The goal of the game is to gain as much money as possible. Subjects need to recognize that some decks are disadvantageous in the long-term, since their high rewards are associated with even higher losses; while the others are more beneficial with their lower rewards followed by moderate punishments. Thus, for a better performance, participants have to refuse higher immediate rewards. The task consists of 100 trials. At the beginning of the test, participants make their decisions under ambiguity, based on their intuitions, since they have no information about the features of the different decks (Brand et al., 2007). Gradually, they can acquire more explicit information about the risks and benefits of each decks. Assuming that this learning occurs, the latter phase of the task can be viewed as a measure of risk-based decision-making (Brand et al., 2007). Given that rejection of high rewards is essential for a better future outcome, one obvious explanation for poor performance on this task can be hypersensitivity to reward and/or decreased sensitivity to punishment (Bechara et al., 1994).

However, further interpretations behind the IGT performance could be possible (i.e. increased sensitivity to punishment and/or decreased sensitivity to reward). Whilst the ABCD version alone does not provide comprehensive information about reward- and punishment-based decision-making processes, a modified “EFGH” version was developed (Bechara et al., 2000). The IGT EFGH measures punishment-sensitivity, since choosing of cards is followed by immediate punishments, and the addition of rewards is occasional. Decks with higher losses provide even higher rewards; thus, these are advantageous in the long-term. In their study, Bechara et al. (2000) reported that patients with OFC/VMPFC lesion performed poorly on both versions of the IGT, which raises that an alternative explanation is needed instead of those limited to the sensitivity to reward or punishment. In the case of this patient group, insensitivity to future consequences may underlie decision-making deficit (Bechara et al., 2000). In contrast, depressed individuals performed poorly on the ABCD version, and showed a normal learning rate on the IGT EFGH in the study of Must et al. (2006). In case of this depressed group, decision-making could be explained by increased reward-sensitivity (or decreased punishment-sensitivity) or by the preference for decks with higher emotional valence due to their reduced emotional reactivity (Must et al., 2006, 2013). Anyhow, usage of both tasks enables deeper knowledge about decision-making processes and it may highlight important contrasts between different groups.

Even though the comprehensive interpretation of decision-making functioning requires both versions, performance of suicidal persons on the IGT EFGH is not known. Furthermore, there is no information about decision-making functioning of individuals experiencing a suicidal crisis. A person who chooses death may be feeling trapped and futureless; hence, it is possible that similar to patients with OFC/VMPFC lesion, suicide attempters do not anticipate the long-term consequences of their decisions, resulting in the preference for choices with better immediate outcomes. Medication-free, recently suicidal depressed patients may perform under the influence of a special cognitive state, which justifies the importance of studying this patient group. Overall, the aim of this study was to investigate the decision-making strategy of depressed patients within 72 h following a suicide attempt by using the ABCD and EFGH versions of the IGT. Poor performance on both tasks was hypothesized.

2. Methods

2.1. Participants

Fifty-nine suicide attempters with a diagnosis of unipolar major depressive disorder and forty-six healthy control volunteers were included in this study. Participants between 18 and 65 years were recruited. Patients and controls were matched for gender and age.

Suicide attempters were hospitalized at the Department of Psychiatry, Faculty of Medicine, University of Szeged, Hungary, and were assessed within 72 h after the attempt. A suicide attempt was defined as a “non-fatal self-directed potentially injurious behaviour with any intent to die” (Koslow et al., 2014), and it was differentiated from other self-destructive behaviours such as self-mutilation (Jollant et al., 2005). Suicidal individuals received all necessary life-saving interventions, but they were free from psychiatric medication at the time of the assessment. Tests were conducted as soon as their condition allowed it, and psychiatric treatment was started following data collection. All participants received the Mini-International Neuropsychiatric Interview (Sheehan et al., 1998). Patients with neurological illnesses, bipolar disorder, substance and alcohol abuse, psychotic disorders, obsessive-compulsive disorders or dementia were excluded. Severity of depressive symptoms was measured by the original version of the Hamilton Depression Rating Scale (HAM-D-17, Hamilton, 1960) in the patient group.

Convenience sampling method was used to recruit control subjects. They were free from psychiatric medication. They had no psychiatric diagnosis. History of a suicide attempt was an exclusion criterion in this group.

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Human Investigation Review Board, University of Szeged (ethical approval number: 2443). Written informed consent was obtained from each participant.

2.2. The Iowa Gambling Task

Decision-making was tested by using two versions of the Iowa

Gambling Task. All participants received standard instructions and were told that the goal of the game is to win as much money as possible. They were informed that the decks are different from each other, the game is not unfair and does not work randomly; therefore, there are better and worse choices.

In the ABCD version, four decks of cards are presented on the screen, labelled as “A”, “B”, “C” and “D” . Each deck contains 40 cards. Participants choose cards multiple times from these decks by clicking on the top card. Following the choices, different values of gained money appears. Rewards are occasionally followed by money losses. Happy or sad faces and sounds appear together with wins and losses. The amount of rewards and the amount and frequency of losses are not randomly generated: there are advantageous and disadvantageous decks. “A” and “B” decks are disadvantageous, associated with immediate higher rewards, but even higher future punishments; while “C” and “D” decks are advantageous long term, providing moderate immediate rewards, but also moderate losses. In the EFGH version, the layout and design is similar to the previous one, but choices are followed by immediate losses, and certain amount of money is sometimes won together with the punishment. Decks are labelled as “E”, “F”, “G” and “H” . Decks “E” and “G” are advantageous, providing high immediate punishments, but even higher future rewards, resulting in an overall gain. Decks “F” and “H” are disadvantageous, associated with lower immediate punishments, but even lower rewards.

The tasks consist of 100 trials. Each deck contains 40 cards, therefore, running out of cards from a deck is possible. For data analysis, selections were divided into five blocks (20 cards in each). Differences between the number of choices from advantageous and disadvantageous decks were compared.

2.3. Statistical analysis

SPSS 24 was used for data analysis.

For continuous variables, the Independent-Samples T Test was used; for categorical variables, the Chi-square test was used in order to compare demographic variables of depressed patients and control subjects. Comparison of the two groups’ performance on the IGT was made by Repeated Measures ANOVA and Repeated Measures ANCOVA with the Bonferroni post hoc test. Partial eta squared was reported as a measure of effect size. The Greenhouse-Geisser correction was applied due to results of Mauchly's Test of Sphericity. A Pearson correlation analysis was used to reveal the interrelationship between decision-making performance and affective state measured by the HAM-D, and between the IGT ABCD and IGT EFGH results in the patient group.

Level of significance was set at $p < 0.05$.

3. Results

Sociodemographic features and the results of subjects are presented in Table 1. Suicide attempters and healthy subjects did not differ in terms of gender ratio ($X^2(1) = 1.883$, $p = 0.170$) and age ($t(103) = 0.646$, $p = 0.519$), but they statistically differ in terms of education level ($t(103) = -4.187$, $p < 0.001$).

Table 1
Demographic characteristics of participants

		Suicide attempters (N = 59)		Healthy control subjects (N = 46)		Analysis		
		N	%	N	%	X^2	*df*	*p*
Gender	Male	18	35.5	20	43.5	1.883	1	0.170
	Female	41	69.5	26	56.5			
		Mean	**SD**	**Mean**	**SD**	***t***	***df***	***p***
Age (years)		35.73	12.25	34.24	10.98	0.646	103	0.519
Education (years)		11.12	2.10	12.98	2.44	−4.187	103	<0.001

The Repeated Measures ANOVA revealed significant interaction effect between factors BLOCKS and GROUPS on the IGT ABCD ($F(3.357, 345.812) = 4.171$, $p = 0.005$, $\eta p^2 = 0.039$), and a trend towards significant differences was shown on the IGT EFGH ($F(3.078, 317.017) = 2.370$, $p = 0.069$, $\eta p^2 = 0.022$). The Bonferroni post hoc analysis confirmed that these results were due to significant between-group differences in block 2 ($F(3.357, 345.812) = 4.171$, $p = 0.04$, $\eta p^2 = 0.039$), block 3 ($F(3.357, 345.812) = 4.171$, $p < 0.001$, $\eta p^2 = 0.039$), block 4 ($F(3.357, 345.812) = 4.171$, $p < 0.001$, $\eta p^2 = 0.039$) and block 5 ($F(3.357, 345.812) = 4.171$, $p = 0.008$, $\eta p^2 = 0.039$) during the IGT ABCD, and block 2 ($F(3.078, 317.017) = 2.370$, $p = 0.007$, $\eta p^2 = 0.022$) and block 3 ($F(3.078, 317.017) = 2.370$, $p = 0.013$, $\eta p^2 = 0.022$) during the IGT EFGH (Fig. 1).

The Bonferroni post hoc test revealed the following within-group differences. During the IGT ABCD, the block-to-block differences were not significant in the suicidal group. However, there was a significant difference between block 1 - block 5 ($F(3.357, 345.812) = 19.146$, $p = 0.045$, $\eta p^2 = 0.157$). In the control group, block 1 differed significantly from the other blocks ($F(3.357, 345.812) = 19.146$, $p < 0.001$, $\eta p^2 = 0.157$ in each pairings). Block-to-block differences were present only between block 1 and block 2 ($F(3.357, 345.812) = 19.146$, $p < 0.001$, $\eta p^2 = 0.157$).

During the IGT EFGH, depressed suicidal participants’ performance was constant statistically. Control subjects’ performance differed significantly between block 1 - block 2 ($F(3.078, 317.017) = 8.482$, $p < 0.001$, $\eta p^2 = 0.076$) and block 3 - block 4 ($F(3.078, 317.017) = 8.482$, $p = 0.38$, $\eta p^2 = 0.076$). Their performance in block 1 differed from block 2 ($F(3.078, 317.017) = 8.482$, $p < 0.001$, $\eta p^2 = 0.076$), block 3 ($F(3.078, 317.017) = 8.482$, $p < 0.001$, $\eta p^2 = 0.076$), but did not differ significantly from block 4 ($F(3.078, 317.017) = 8.482$, $p = 0.737$, $\eta p^2 = 0.076$) and block 5 ($F(3.078, 317.017) = 8.482$, $p = 0.079$, $\eta p^2 = 0.076$). As learning tendencies can be followed up until block 4 in the healthy comparison group, a Repeated Measures ANOVA was conducted during the first three blocks of the IGT EFGH, which revealed a significant interaction between factors BLOCKS and GROUPS ($F(1.609, 165.735) = 5.638$, $p = 0.008$, $\eta p^2 = 0.052$).

Since the two groups were not matched for education, a Repeated Measures ANCOVA was conducted with “years of education” as the covariate. The covariate had a significant effect on performance during the ABCD version ($F(3.444, 351.319) = 4.791$, $p = 0.002$, $\eta p^2 = 0.045$); while it could not be observed during the EFGH ($F(3.077, 313.859) = 0.561$, $p = 0.647$, $\eta p^2 = 0.005$). The interaction between BLOCKS and GROUPS ($F(3.444, 351.319) = 1.644$, $p = 0.172$, $\eta p^2 = 0.016$) was no longer significant on the IGT ABCD after controlling for “years of education”. However, the post hoc test still showed a trend towards between-group differences in block 2 ($F(3.444, 351.319) = 1.644$, $p = 0.063$, $\eta p^2 = 0.016$), and significant differences in block 3 ($F(3.444, 351.319) = 1.644$, $p = 0.003$, $\eta p^2 = 0.016$) and block 4 ($F(3.444, 351.319) = 1.644$, $p = 0.006$, $\eta p^2 = 0.016$).

There was no significant correlation between the IGT ABCD and IGT EFGH net scores in the patient group ($r(57) = 0.212$, $p = 0.107$).

Suicide attempters scored an average of 17.754 points (SD = 6.384) on HAM-D. There was no significant correlation between performances on the IGT tasks and HAM-D scores (ABCD: $r(55) = -0.144$, $p = 0.286$; EFGH: $r(55) = 0.073$, $p = 0.591$).

4. Discussion

This study presented the performance of depressed individuals, who tried to end their lives within the previous 72 h. Confirming the hypothesis, recent suicide attempters diagnosed with unipolar major

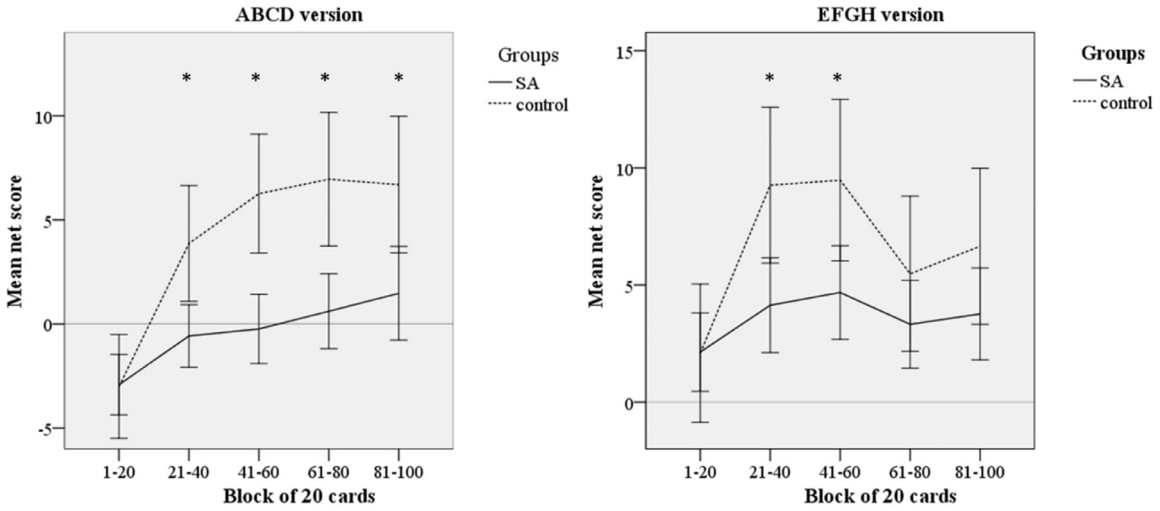

Fig. 1. Changes in decision-making performance of 59 suicide attempters (SA) and 46 control subjects (control) during the five blocks of two versions of the Iowa Gambling Task.
Mean net scores (disadvantageous minus advantageous choices) and standard error means are shown. The * symbols indicate significant statistical differences ($p < 0.05$).

depressive disorder performed poorly on the IGT ABCD compared to healthy comparison subjects; while a trend towards between-group differences was shown on the IGT EFGH. Suicide attempters' decision-making was independent from severity of depressive symptoms.

Suicidal persons showed almost completely constant performance at different stages of the IGT ABCD and EFGH: significant improvement could only be seen between block 1 and block 5 on the IGT ABCD. In contrast, results of the control individuals increased significantly after the first block of both versions. It is an important difference, since at the beginning of the game, participants should get familiar with the rules; therefore, decision-making performance in risky situations can be observed in the second part of the task (Brand et al., 2007). Significant improvement following the first block may indicate that control subjects identified advantageous decks quickly and they preferred them; while in the case of depressed suicidal individuals, learning tendencies could not be detected.

It is important to notice, that a significant drop in control participants' performance could be seen following block 3. However, their poorer performance in the last two blocks can be explained by the quick identification of the advantageous strategy, causing the running out of cards from the beneficial decks (Davis et al., 2008). Counterbalancing of the order of the IGT versions was not implemented in this study: learning effect following the IGT ABCD could not be controlled. General rules of the IGT were already known at the beginning of the IGT EFGH; thereby, sooner identification of advantageous decks could be present, which can explain the running out of advantageous cards in case of the control subjects. Nevertheless, their worsened performance in block 4 moderated the adequate comparison of the groups. Hence, it should be highlighted that statistical analysis of the first 3 blocks revealed significantly differences between the IGT EFGH performance of the groups.

Anyhow, patients' decision-making can be regarded as disadvantageous on both versions of the IGT. Findings are in line with previous studies reporting deficient decision-making performance of depressed suicide attempters on the IGT ABCD (Jollant et al., 2005; Westheide et al., 2008; Oldershaw et al., 2009). To the authors' knowledge, suicide attempters' performance on the IGT EFGH was not assessed before; thus, this is the first study providing information about the comprehensive decision-making profile of this group. Without the usage of the IGT EFGH, results of recently suicidal individuals could be explained by increased reward-sensitivity or decreased punishment-sensitivity. Results of the EFGH showed opposite tendencies; therefore, it questioned the applicability of reward- and punishment-based models in this group. Accordingly, the additional information of the IGT EFGH allows to more precisely explain how the reported decision-making pattern may relate to a suicidal crisis.

Most individuals in a suicidal crisis feel themselves to be dislikeable, incompetent, guilty (Baumeister, 1990), trapped, helpless, hopeless (van Heeringen and Marusic, 2003) and demonstrate dichotomous thinking and overgeneralization (Jager-Hyman et al., 2014). Accordingly, patients in this study experienced psychological pain and were unmotivated, unsociable and hopeless within 72 h after their attempt. The desire to escape from negative circumstances immediately often results in self-destructive behaviour, revealing that suicide attempters may have a short-term focus (Baumeister, 1990). This is line with the results of the present study: participants with a suicide attempt preferred decks with the best immediate outcomes, causing poor performance on both IGT versions. Bechara et al. (2000) explained such a decision-making profile in the case of patients with OFC/VMPFC lesion also by myopia for future consequences. However, it should be clarified whether recent suicide attempters do not care for the future for psychological reasons, or if they cannot plan for it because of other contributing neuropsychological dysfunctions. Prediction of the near future is based on learning models of action-dependent outcomes and may require several cognitive skills.

Consequently, more functions were reported to be essential for proper IGT performance including working memory, which holds information long enough for attention, evaluation and reasoning strategies (Bechara et al., 1994), and cognitive inhibition, which allows participants to reject choices seeming to be immediately advantageous (Bechara et al., 2000). Differentiation of risky and safe choices due to immediate and long-term value-attribution is also important (Jollant et al., 2010), and includes several functions. For instance, it presumes processes associate to the DLPFC, which provides future reward predictions (van Heeringen et al., 2011), the computation of subjective value mediated by the amygdala and striatum (Phelps et al., 2014), and learning from reinforcement besides the functions moderated by the OFC/VMPFC (Jollant et al., 2010; Phelps et al., 2014). Although the role of executive functions and explicit understanding in decision-making was reported by Ochoa et al. (2013), others found that decision-making performance is independent from other cognitive processes, for example from executive functions measured by the Wisconsin Card Sorting Task (Must et al., 2006) or cognitive control functions and attention (Richard-Devantoy et al., 2013; Hoehne et al.,

2015). Furthermore, explicit understanding was not reported as a sufficient condition for advantageous decision-making in suicide attempters (Jollant et al., 2013), which points out that other processes, like implicit bodily signals, known as somatic markers, should also be taken into account (Bechara et al., 1994; Jollant et al., 2013). In summary, results of the IGT tasks revealed that recently suicidal individuals made their decisions by considering factors relevant in the short-term, which could be explained partly by cognitive deficits and also by psychological factors.

As regard as cognitive abilities may mediate the IGT performance and groups were not matched for education level, it is important to discuss the possible effect of this factor in this study. According to the statistical analysis, years of education had a significant effect on learning tendencies during the IGT ABCD and it reduced between-group differences as a covariate factor. Education level was reported to have a significant effect on the IGT performance also by Davis et al. (2008). Higher educational level may affect rational decision-making through the higher acquired knowledge (Davis et al., 2008). However, lower levels of education could be a relevant risk factor for lifetime major depressive disorder (Kessler et al., 2003) and it was reported as the highest risk factor for suicidal behaviour among individuals with suicidal thoughts (Choi et al., 2017). Therefore, findings of this study may represent the depressed suicidal group's characteristics and may reflect to the interrelation between poorer cognitive abilities and suicidal behaviour.

Anyhow, disadvantageous decision-making measured by the IGT in a special suicidal subgroup was reported. Gorlyn et al. (2013) raised the possibility that the IGT deficit may be present just in those suicidal patients who have higher risk for a current suicide attempt; therefore, it is rather a state-dependent factor, than a trait-like characteristic. Deisenhammer et al. (2018) measured IGT performance of persons who attempted suicide within a maximum of six months, while they suggested more pronounced cognitive alterations during this sensitive period. Other researchers also applied a tighter time frame (Westheide et al., 2008). Overall, poor decision-making performance is regarded as dependent on actual suicidal intentions and behaviour by these studies. In the presented study, depressed patients were measured following a suicide attempt as soon as possible; therefore, it provides valuable information about decision-making functioning in suicidal state.

Design of the research does not allow to reveal whether the found decision-making deficits are state or trait-dependent. However, data published on depressed patients with a lifetime history of a suicide attempt could have an impact on the interpretation of the present findings. Previously suicidal depressed patients showed significantly poorer performance than healthy subjects on the IGT ABCD, but their performance did not differ significantly from each other on the IGT EFGH (Hegedűs et al., 2015). Thus, depressed subjects with a history of a suicide attempt performed similarly to depressed individuals with no history of suicidal behaviour (Must et al., 2006), while depressed patients with a recent attempt differed from them. Therefore, suicidal participants' preference for disadvantageous decks on both versions may be a characteristic of the suicidal crisis state.

No correlation between IGT net scores and HAM-D scores shows that the reported decision-making profile was not associated with the symptomatology of the participants' major psychiatric diagnosis. It is an interesting finding, since suicide attempts are regarded to have a cathartic effect, resulting in the short-term improvement in the symptoms of depressive state (van Praag and Plutchik, 1985; Rihmer and Rutz, 2009). Results of this study suggest that cognitive symptoms do not improve immediately following the attempt.

It is important to highlight that participants were free from psychiatric medication at time of the assessment, which strengthen the results of this study. Psychiatric medication, especially benzodiazepines, could have long- and short-term effects on cognitive functioning (Buffett-Jerrott and Stewart, 2002).

This study has limitations. Firstly, participants were not matched for education. Secondly, administration of the two versions of the IGT was not counterbalanced, which raises some methodological concerns. Thirdly, type of suicide attempts (violent or non-violent) and history of previous attempts were not collected, although these variables could mediate the findings. Finally, inclusion of depressed patients with a history of a suicide attempt could provide clearer answer if a state-dependent decision-making profile was captured.

In summary, the comprehensive decision-making profile of depressed subjects with a recent suicide attempt was reported. The presence of decision-making deficits in this special subgroup was confirmed. Information about patients following a suicide attempt contributes to a better understanding of why an individual engages herself or himself in suicidal acts. Further longitudinal studies examining other cognitive functions could have an even stronger impact on knowledge about the suicidal state. The identification of state-dependent cognitive alterations may lead to the possibility of the compilation of a neuropsychological test battery indicating suicide crisis.

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Declaration of interest

None.

Author's contribution

All authors have materially participated in the research and/or article preparation. All authors have approved the final article.

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Supplementary materials

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II.

PLOS ONE

RESEARCH ARTICLE

Temperament, character and decision-making characteristics of patients with major depressive disorder following a suicide attempt

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Abstract

Background

Multiple psychological factors of suicidal behaviour have been identified so far; however, little is known about state-dependent alterations and the interplay of the most prominent components in a suicidal crisis. Thus, the combined effect of particular personality characteristics and decision-making performance was observed within individuals who recently attempted suicide during a major depressive episode.

Methods

Fifty-nine medication-free major depressed patients with a recent suicide attempt (within 72 h) and forty-five healthy control individuals were enrolled in this cross-sectional study. Temperament and character factors, impulsivity and decision-making performance were assessed. Statistical analyses aimed to explore between-group differences and the most powerful contributors to suicidal behaviour during a depressive episode.

Results

Decision-making and personality differences (i.e. impulsivity, harm avoidance, self-directedness, cooperativeness and transcendence) were observed between the patient and the control group. Among these variables, decision-making, harm avoidance and self-directedness were shown to have the strongest impact on a recent suicide attempt of individuals with a diagnosis of major depressive disorder according to the results of the binary logistic regression analysis. The model was significant, adequately fitted the data and correctly classified 79.8% of the cases.

Conclusions

The relevance of deficient decision-making, high harm avoidance and low self-directedness was modelled in the case of major depressed participants with a recent suicide attempt;

meaning that these individuals can be described with the myopia for future consequences, a pessimistic, anxious temperament; and a character component resulting in the experience of aimlessness and helplessness. Further studies that use a within-subject design should identify and confirm additional characteristics specific to the suicidal mind.

Introduction

Suicide represents a major public health problem worldwide as regards it takes approximately 800 000 lives per year and therefore considered as one of the leading causes of death [1]. In Europe, 10–30 attempts were reported for each completed suicides [2]. Considering that a suicide attempt is one of the most important risk factors of a completed suicide [3] and the strongest risk factor of a further suicide attempt [4], this data highlights the significance of better understanding the background of a suicide attempt.

Numerous distinct biological, social and psychological factors have been linked to suicide attempt; however, the application of multidimensional approaches could better contribute to understanding the antecedents of such a serious outcome. The present study aims to highlight some potential psychological factors characterising the status of major depressed individuals with a recent suicide attempt.

The significance of cognitive factors such as decision-making, problem-solving and autobiographical memory; personality correlates, such as impulsivity, hopelessness and particular temperament and character dimensions in suicidal behaviour have been confirmed (see [5–7]), although this list is non-exhaustive. Many studies focus on patients with a history of a lifetime suicide attempt, revealing some major trait-like vulnerability factors for suicidal behaviour (e.g. sensitivity to social stress tied to attention deficits, reward dependence; impaired problem-solving, hopelessness, impulsivity and aggression [6], decision-making [8]). However, studying the state following a suicide attempt is also important, since exploring the mind still in the period of a suicidal crisis may help us to identify individuals with an acute risk of suicide in the future.

As regards studies in which patients were treated within a maximum of two weeks following a suicide attempt, patients with major depressive disorder were characterised by higher impulsivity [9], immature defence mechanisms [10] and specific temperament and character factors (i.e. higher harm avoidance and lower self-directedness, [11]). As for cognitive aspects, research has focused on deficits in cognitive inhibition [12], pronounced cognitive impairment [13] and poor decision-making performance [14] among depressed patients with a recent suicide attempt.

These findings indicate that serious suicidal intent may emerge on the basis of pronounced neurocognitive and personality alterations. Among these variables, the study presented focused on decision-making as a cognitive function, impulsivity and Cloninger's temperament and character factors [15] as personality components.

Decision-making is a higher-order cognitive function requiring numerous cognitive skills. Its different aspects can be measured by distinct tasks, among which decision-making in ambiguous and risky situations was observed in this research with the help of the Iowa Gambling Task's (IGT) two versions [16, 17]. Poor overall performance and the absence of learning effect could be important indicators of suicidal behaviour associating with serotonergic impairments in the orbitofrontal cortex / ventromedial prefrontal cortex [8].

Impulsivity is a multifactorial, partly heritable construct [18], which can refer to different behavioural or personality manifestations of impaired self-regulation. Its personality aspect will be discussed in this paper. In this manner, impulsivity can refer to the lack of deliberation and persistence [19]; novelty seeking behaviour, rapid processing of information and the inability to delay gratification and to forethought before acting [20]. Although impulsivity has a complex neurobiological basis, its strong associations with the serotonergic system via 5-HT activity [18] and the dopaminergic system [21] can be highlighted.

Cloninger's psychobiological model differentiates four temperament (harm avoidance, novelty seeking, reward dependence, persistence) and three character (self-directedness, cooperativeness, transcendence) factors [15]. Temperament is the partially heritable "disposition of a person to learn how to behave, react emotionally, and form attachments automatically by associative conditioning", while character refers to the self-regulatory aspects of personality linking to learning and memory systems of intentionality and self-awareness and also showing heritability [22–24].

In the light of the above, the aim of the present study is to assess the possible importance of particular personality and cognitive factors of medication-free individuals with a diagnosis of major depressive disorder within 72 h following their suicide attempt. In an accompanying paper, comprehensive decision-making profile was reported in the same cohort of participants [14]. To broaden our scope, the present study also takes impulsivity, temperament and character factors into account and weighs the possible predictive power of these correlates on major depressive individuals' status following a suicide attempt.

Concerning the results of the accompanying paper reflecting poor decision-making performance with the inability to anticipate future consequences in the patient group, importance of decision-making was hypothesized in the presented model. Relating to the observations of Eric et al. [11] examining patients with similar inclusion criteria, higher harm avoidance and lower self-directedness were hypothesized to be specific to the state of individuals who attempted suicide recently during a depressive episode. Furthermore, predictive value of these variables was assumed. Regarding impulsivity, between-group differences and its significance in the model was hypothesized.

Methods

Participants

Fifty-nine depressed individuals with a recent suicide attempt (mean age: 35.7, SD: 12.3; 41 female, 18 male) and forty-five healthy control subjects (mean age: 34.5, SD: 11; 25 female, 20 male) were recruited in this study.

Medication-free in-patients at the Department of Psychiatry, Faculty of Medicine, University of Szeged with a diagnosis of major depressive disorder and with a recent suicide attempt (within 72 hours) were enrolled. Individuals between 18 and 65 years of age were included. A "non-fatal self-directed potentially injurious behaviour with any intent to die as a result of the behaviour" was regarded as a suicide attempt [25]. Patients with neurological disorders, bipolar disorder, substance related disorders, schizophrenia spectrum disorders and obsessive-compulsive disorders were excluded.

Control participants were matched for age and sex, had never attempted suicide, had no psychiatric diagnosis and were free from psychiatric medication. They were recruited via convenience sampling method and their assessment took place in the outpatient exam rooms of the clinic.

The study was carried out according to the Declaration of Helsinki and was approved by the Human Investigation Review Board, University of Szeged (ethical approval number: 2443).

Written informed consent was obtained from all the participants after a comprehensive description of the study.

Measures

Diagnoses were made with the Mini-International Neuropsychiatric Interview [26].

Impulsivity was measured by the Barratt Impulsiveness Scale (BIS-10) [27]. This paper-and-pencil scale consists of 34 items and has three subscales: motor impulsivity, cognitive impulsivity and non-planning impulsivity. Temperament and character factors were assessed with the original version of the Temperament and Character Inventory [15]. This self-reporting measure consists of 240 "true" or "false" items that measure four temperament factors, harm avoidance, novelty seeking, persistence and reward dependence, and three character dimensions, self-directedness, cooperativeness and self-transcendence.

Decision-making ability was assessed with two versions of the Iowa Gambling Task (the IGT ABCD version [16] and the IGT EFGH version [17]). This computerized game captures decision-making in ambiguous and risky situations. Participants choose cards 100 times from four decks with different properties. The ABCD version contains two decks with small immediate rewards, but with tolerable future losses and two others with high immediate gains paired with significant future losses. Decks with high immediate punishments with even higher rewards and decks with small losses, but insignificant future gains are present in the EFGH version. Therefore, for a better overall outcome, acceptance of lower immediate rewards pays off with the ABCD version (it is sensitive to reward), and toleration of high immediate losses does so with the EFGH version (it is sensitive to punishment). Test performance can be evaluated based on overall net scores and sub-scores for every set of 20 choices (1–20, 21–40, 41–60, 61–80 and 81–100).

Statistical analysis

Independent samples t-test and chi-square test were used in order to observe sociodemographic between-group differences. One-way multivariate analysis of covariance (MANCOVA) was conducted to reveal statistical differences on personality and cognitive variables between the two groups, while controlling for age as covariate regarding its possible mediating effect on the measured components [28, 29]. Bonferroni post-hoc analyses revealed adjusted between-group differences. Effect sizes were indicated by partial eta-squared. Binary logistic regression with a stepwise method of forward likelihood ratio was conducted to explore that among the observed variables, which are the strongest indicators of a suicide attempt during a major depressive episode and whether they can be included into a model with sufficient prediction value. Overall decision-making performance, impulsivity and temperament and character factors were set as covariates and age was set as indicator factors. Fitness of the model was monitored with the Hosmer-Lemeshow test.

The level of significance was set at $p < 0.05$. SPSS 24 [30] was used for data analysis.

Results

Depressed individuals with a recent suicide attempt and healthy control individuals were compared with regard to age and sex. These analyses did not show significant differences (age: $t(103) = 0.646$, $p = 0.519$); sex: ($\chi^2(1) = 1.883$, $p = 0.170$).

There was a significant difference between the two groups on the combined effect of dependent variables after controlling for age (Pillai's trace = 0.451; $F(10,87) = 0.536$, $p < 0.001$, $\eta p^2 = 0.54$). Adjusted personality and decision-making between-subject differences are presented in Table 1.

Table 1. Adjusted personality and decision-making differences between individuals with a diagnosis of major depressive disorder and a recent Suicide Attempt (SA) and Healthy Controls (HC).

	SA (N = 59)	HC (N = 45)	Post-hoc test			
	Mean (SD)	Mean (SD)	*F*	*df*	*p*	ηp^2
BIS/Total	71.54 (12.71)	61.31 (9.78)	19.66	1	<0.001	0.17
TCI/NS	18.52 (6.00)	20.2 (5.71)	1.44	1	0.302	0.02
TCI/HA	21.91 (7.00)	12.49 (5.90)	50.58	1	<0.001	0.35
TCI/RD	15.41 (3.08)	16.29 (3.00)	1.65	1	0.202	0.02
TCI/P	4.74 (2.51)	4.71 (1.83)	0.03	1	0.955	<0.01
TCI/SD	23.63 (6.14)	31.13 (4.04)	47.93	1	<0.001	0.33
TCI/C	28.06 (6.60)	31.13 (4.04)	6.57	1	0.012	0.06
TCI/T	15.35 (6.97)	11.22 (5.35)	10.63	1	0.002	0.10
IGT/ABCD	-1.94 (21.83)	20.27 (34.32)	14.58	1	<0.001	0.13
IGT/EFGH	16.81 (23.67)	32.36 (42.52)	4.70	1	0.033	0.05

Abbreviations: BIS (Barratt Impulsiveness Scale), TCI (Temperament and Character Inventory), NS (novelty seeking), HA (harm avoidance), RD (reward dependence), P (persistence), SD (self-directedness), C (cooperativeness), T (transcendence), IGT (Iowa Gambling Task).

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After controlling for age, stepwise forward binary logistic regression model included IGT ABCD net score, harm avoidance and self-directedness in the equation from the observed components presented in Table 1. These variables added significantly to the prediction: IGT ABCD net score ($\chi^2 = 7.459$; df: 1; $p = 0.006$), harm avoidance ($\chi^2 = 7.502$; df: 1; $p = 0.006$), and self-directedness ($\chi^2 = 6.763$: 0.169; df: 1; $p = 0.009$). No indication of multicollinearity was found among these variables (VIF below 2.247 for every variable in the model). The baseline model ($\chi^2 = 0.816$; df: 1; $p = 0.366$) had an accuracy of 54.5% overall percentage. The Hosmer–Lemeshow test (χ^2: 9.262; df: 8; $p = 0.321$) indicates that this model adequately fitted the data. The model was significant (χ^2: 58.108; df: 5; $p < 0.001$), explains 59.4% of the variance (Nagelkerke R^2) and correctly classified 79.8% of cases.

Discussion

This study observed significant decision-making, impulsivity, temperament and character differences between medication-free major depressed individuals with a recent suicide attempt and healthy control participants. Besides, it presented a model indicating that among these variables, poor decision-making on the IGT ABCD, high harm avoidance and low self-directedness were the most powerful characteristics of the patients. Furthermore, these three factors had a significant predictive value and classify 79.8% of participants correctly. Therefore, hypotheses regarding decision-making, harm avoidance and self-directedness were confirmed. Higher impulsivity was indeed present among patients; however, its assumed importance in the model was not confirmed.

The specific role of decision-making in depressed patients with a previous suicide attempt was reported earlier in several studies [31], even in comparison to major depressive individuals with no history of a suicide attempt [8]. This research also confirmed the relevance of decision-making among depressed individuals with a suicide attempt, since both IGT versions differentiated patients from control participants and IGT ABCD was included in the model presented. Importance of the reported decision-making performance was discussed in detail in the accompanying paper [14]. In summary, poor decision-making could indicate reward-sensitivity (in the IGT ABCD) or punishment-sensitivity (in the IGT EFGH). However, depressed individuals with a recent suicide attempt performed poorly on both versions and

thus alternative interpretations are needed. Since decision-making is a higher-order neuropsychological function requiring numerous cognitive skills, its deficit may represent a complex cognitive disturbance. On the other hand, prediction of the near future is essential for advantageous decision-making during the IGT; thus, poor performance may be linked to the myopia for future, which is one of the major characteristics of the suicidal mind.

As regards personality components, high harm avoidance, low self-directedness, low cooperativeness, high transcendence and high impulsivity could be observed in case of depressed individuals with a recent suicide attempt.

In terms of suicidal behaviour, impulsivity could play an important role in the transition of suicidal ideations into attempt [32] and could interact with depressive state and hopelessness [33]. Impulsivity was indeed proved to be a possible characteristic of depressive state and an important indicator of suicide risk among different groups of individuals: distinct aspects of impulsivity could differentiate persons with mental disorders from healthy controls [34], depressive states from manic states [33], and differ among patients with or without a history of a suicide attempt [9, 34]. Besides, certain facets could be sensitive for suicide ideation or intent [32, 35, 36].

Since the study presented revealed higher impulsivity of major depressed individuals with a recent suicide attempt even after controlling for age, findings could be regarded as consistent with previous research. However, impulsivity was not included among the most relevant variables of the model. It is important to note that the above mentioned studies highlighted mainly between-group differences regarding impulsivity and therefore gave moderate information about its statistical power. A meta-analysis revealed small effect size of impulsivity on suicidal behaviour [37]; therefore, less robust power of this factor in the model presented also corresponds to previous findings. It could be challenging to explore the role of impulsivity on suicidal behaviour with paper-pencil tests–its behavioural indicators may represent a more relevant predictive power.

Concerning temperament and character factors, a fearful, pessimistic (high harm avoidance) temperament style and characteristics of aimlessness, blaming (low self-directedness), hostility, self-centeredness (low cooperativeness), altruism, spirituality (high transcendence) can be highlighted among depressed individuals with a recent suicide attempt. Although, interpretation of personality constellations could be more expedient, since high transcendence in itself may be indeed adaptive; however, its association with low cooperativeness and self-directedness could indicate "schizotypal" features [38].

The observation of possible interactions between high harm avoidance and low self-directedness could be also essential, since these components were included in the built model. Low harm avoidance and high self-directedness relate to resilience, the ability to maintain a healthy mental state in stressful situations [39]. The model presented shows an inverse personality constellation, indicating that adaption to different life-challenges is affected in this sample. As regards their possible importance in suicidal behaviour, high harm avoidance [5, 6, 40, 41] and low self-directedness has been reported in several studies [42, 43].

All in all, the model presented suggests that I) the inability to make decisions according to an assessment of possible future consequences, II) a pessimistic and shy temperament, and III) loss of willpower and goal-orientation may be the most powerful characteristics of major depressive individuals with a recent suicide attempt when compared to healthy controls. Furthermore, accuracy of the prediction is relatively high, meaning that patients can be differentiated with good probability from healthy persons based on these variables.

It is important to note that, although the results are mixed and non-exclusive, neural networks with serotonergic modulation seem to play an important role in these two personality factors [44, 45] and in decision-making [8], raising the possibility that changes in the serotonergic system may affect these components and link them. Besides, the orbitofrontal cortex

can be highlighted as an important structure connecting both to harm avoidance [46, 47] and in decision-making functioning [8]–including functional changes during decision-making in ambiguous and risky situations [48].

These findings present the status of major depressed patients within 72 h following their suicide attempt. However, it should be discussed whether these alterations can be regarded as trait-like vulnerability factors for suicide or state-like phenomena that characterise the suicidal mind. As for poor performance on the IGT, there is no consensus on whether this is a trait- or state-dependent factor. Some studies support the former hypothesis [8]; however, analysis of a more comprehensive decision-making profile raises the possibility that more pronounced alterations may present during a suicidal crisis state [14]. As for harm avoidance, temperament factors are commonly referred to as relatively stable phenomena, but it should be highlighted that they can be modified by behavioural conditioning [22]. Besides, severity of depressive symptoms could alter harm avoidance [49–51], which means that the time of the assessment may be important even in the case of this temperament factor. Furthermore, capturing distinct states of mind could reveal differences independently of depressive symptom severity [11, 52], emphasizing the dynamic changes following a suicide attempt. If we take low self-directedness into account as well, its state-like alterations specific to suicidal behaviour can also be observed: it differentiates major depressed individuals with suicidal ideations from non-ideators [40, 53]. In conclusion, even if these factors can be regarded as trait components of suicidal behaviour, their pronounced changes may be specific to suicidal crisis states as well, showing the importance of the time of the assessment.

In summary, this study observed and discussed the relevance of distinct psychological factors among individuals with the diagnosis of major depressive disorder, who attempted suicide within 72 h. The most important finding of this study is that decision-making performance on the IGT ABCD, harm avoidance and self-directedness together could have a predictive value on attempting suicide during a depressive episode. Alterations in the serotonergic system and the orbitofrontal cortex may connect these factors. Further components related to these pathways should thus be taken into account when assessing potential risk factors for a suicidal crisis. Moreover, the fact that this model contains both cognitive and personality dimensions raises the importance of multidimensional approaches. Assessing prediction values within individuals with recent, past or no history of a suicide attempt would also be essential in order to compile clinical test-batteries sensitive for acute suicide crisis.

This study has limitations, of which the lack of a depressed inpatient control group with a past suicide attempt or without a history of a suicide attempt is the most relevant, because it limits the possibility of a suicidal state-specific interpretation. Further studies should explore other possible psychological dimension specific to suicidal crisis. In addition, recruitment of persons with a past history of a suicide attempt as control participants or a within-subject study design may also add to the existing research.

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