Psicothema

Assessment of different components of executive function in grief

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Abstract

Background: Intense and complex symptoms of grief seem to be related to a series of biases and difficulties in areas such as attention, autobiographical memory and problem solving. However, studies of neuropsychological performance have reported contradictory evidence. The role of executive function (EF) in bereaved individuals has not been systematically studied by differentiating between its components. **Method:** A total of 38 participants who had experienced the death of a loved one participated in this study. They were divided into two groups based on the intensity of their symptoms. They underwent neuropsychological assessments that included measures of flexibility, inhibition, working memory and emotional decision-making. **Results:** Group differences were found in the parts of the emotional decision-making task that assessed decisions made under risk. Considering each participant's level of education and emotional variables, the symptoms of grief predicted a substantial variance in their performance in the decision-making task. **Conclusion:** Intense symptoms of grief seem to be related to poorer emotional decision-making performance but not to flexibility, inhibition or working memory.

Keywords: Neuropsychology, complicated grief, bereavement, executive function, decision-making.

Resumen

Evaluación de diferentes componentes de la función ejecutiva en procesos de duelo. **Antecedentes:** los sentimientos y complejos síntomas que pueden asociarse al duelo se han relacionado con dificultades en áreas como la atención, la memoria autobiográfica o la resolución de problemas. Aquellos que han evaluado dimensiones neuropsicológicas han mostrado resultados contradictorios, y el rol de las funciones ejecutivas en población adulta experimentando duelo intenso no ha sido estudiado. **Método:** tomaron parte un total de 38 participantes que habían experimentado la muerte de un ser querido. Fueron divididos en dos grupos dependiendo de la intensidad de los síntomas de duelo (altos frente a bajos). Realizaron una evaluación neuropsicológica que incluyó tareas de flexibilidad, inhibición, memoria de trabajo y toma de decisiones emocionales. **Resultados:** se encontraron diferencias entre los grupos en la toma de decisiones emocionales para aquellos bloques centrados en las decisiones de riego. Controlando por el nivel educativo y los niveles de ansiedad los resultados indicaron que los síntomas de duelo predecían una parte importante de la varianza en la toma de decisiones emocionales. **Conclusiones:** la intensidad del duelo parece ir asociada a dificultades en la toma de decisiones emocionales.

Palabras clave: neuropsicología, duelo complicado, duelo, función ejecutiva, toma de decisiones.

The experience of the death of a loved one is a major and central experience in life, which has been associated with different trajectories and outcomes. The vast majority of people who go through the process of grief eventually overcome it (Bonanno & Diminich, 2013). However, between 10% and 15% of them find remarkable emotional obstacles and may develop long-term (that continue for at least six months) symptoms of grief, such as recurrent sadness, anger, bitterness, loss of life meaning, rumination and difficulty accepting the loss (Maccallum & Bryant, 2013). This constellation of symptoms is currently called complicated grief (CG).

During the last decades, a great deal of research has been conducted to distinguish between adaptive and non-adaptive patterns of grief and the specific emotional dysregulations that characterize CG. Currently, the influences of intense symptoms of grief on a wide range of neuropsychological variables are being considered in older and young adults. A central aspect of neuropsychological performance is executive function (EF). EF can be defined as a series of mental and behavioral processes and competences that sustain and help regulate different cognitive and emotional processes (Chan, Shum, Toulopoulou, & Chen, 2008; Diamond, 2013; Verdejo-García & Bechara, 2010). Traditionally, a distinction has been made between two components of EF: (a) a "cold" component that includes cognitive abilities such as verbal reasoning, attention and cognitive flexibility and (b) a "hot" component that includes emotion regulation or emotional decision-making (Chan et al., 2008).

In young and older adults experiencing grief, several studies have reported contradictory results regarding neuropsychological and EF performance. In older adults, impairments in cold EF have been reported. For example, participants experiencing intense grief had lower scores in verbal fluency, attention, working memory, and semantic memory (Rosnick, Small, & Burton, 2010; Ward,

Mathias, & Hitchings, 2007; Xavier, Ferraz, Trentini, Freitas, & Moriguchi, 2002). A longitudinal epidemiological study showed that widows had poorer EF than married women during the first years after the death of their husband (Vidarsdottir et al., 2014). However, some of these results were better explained by the levels of anxiety and depression (Ward, Mathias, & Hitchings, 2007) or by socio-demographic variables such as gender and age (Rosnick et al., 2010). Nevertheless, other studies comparing older adults dealing with complicated and non-complicated grief did not find differences in working memory or set shifting when they were assessed by neuropsychological tests (O'Connor & Arizmendi, 2014).

The literature on younger adults is characterized by the same pattern of results regarding the cold and hot components of EF. Hall et al. (2014) assessed the EF, visuospatial performance, language, memory, attention and orientation of a large number of participants and only found differences in the visuospatial dimension in the CG group. Saavedra Pérez et al. (2014), who performed a more exhaustive assessment of EF, described lower scores on processing speed and word fluency for those experiencing CG. However, the reported effect sizes were low, and the clinical relevance of these results was not clearly stated (Hall et al., 2014).

To our knowledge, few studies have addressed the role of hot EF in adults. Maccallum and Bryant (2010a) studied decision-making and discovered that participants with CG had more trouble completing a problem-solving task and used less effective strategies and solutions. Recently, Maccallum and Bonnano (2015) reported impairment in future reward discounting. Moreover, studies that outline the central role of emotional bias in CG have shown remarkable consistency. Death-related stimuli are processed differently by participants with CG, who show slower reaction times when responding to death-related words (Maccallum & Bryant, 2010b). Core aspects of grief, such as elevated rumination, have also been associated with impaired inhibition for grief-related information only (Delespaux & Zech, 2015). Finally, autobiographical memory seems to be impaired in CG; subjects reported memories that were less specific both when remembering the past and when imagining the future under conditions that did not relate to the deceased (Robinaugh & McNally, 2013).

In sum, there appear to be differences in a range of neuropsychological variables (both cognitive and emotional) for those with CG. However, it seems that aspects relating to emotions may have higher clinical significance than purely cognitive aspects (Hall et al., 2014; Maccallum & Bryant, 2013).

To our knowledge, no previous study has specifically assessed the roles of different components of EF (including measures of cold and hot EF) in adults experiencing grief while considering the current intensity of their symptoms. This topic is highly relevant to both researchers and clinicians who want to understand the outcomes of grief and to plan adequate interventions. Although there is a wide range of proposals regarding the components of EF (Chan et al., 2008), in this preliminary study, we have assessed four classical components from both cold and hot perspectives: flexibility, inhibition, working memory and emotional decision-making (Verdejo-García & Bechara, 2010).

Therefore, the objectives of this study are: (a) to assess the differences between various components of EF (flexibility, inhibition, working memory and decision-making) according to the current intensity of the symptoms of grief (high vs. low) and

(b) to predict a relationship between the current intensity of grief symptoms and the performance of the EF components that differed between the groups (high vs. low) when the subjects' educational levels and emotional variables were accounted for.

Method

Participants

A total of 44 participants were included in this study (see Table 1). They were recruited from the Clinical Unit of the Faculty of Psychology in Granada, the Palliative Care Unit of San Cecilio Clinical Hospital (Granada, Spain) and from two parents' associations for grief and bereavement in Jaén and Albacete (Spain). The inclusion criteria were a) having experienced the death of a loved one more than six months ago and b) being at least 18 years of age. The exclusion criteria were a) being unable to write or read, b) having a preexisting neurological or cognitive disorder and c) having an extreme score on the variables of depression and anxiety. Six participants were excluded due to the exclusion criteria. The final sample comprised 38 participants (mean age = 42.79 years, SD = 12.59; 76.3% women, most of whom had lost a parent (39.5%) or a son (28.9 %)).

The Texas Revised Inventory of Grief was used to divide the sample based on the median scores of the "Present Feelings" subscale, which assesses the intensity of current grief symptoms. The median was selected to avoid the effect of extreme values due to the sample size. The median score of the sample was of 28.5 (in this instrument, a higher score indicates fewer symptoms of grief, and a lower score indicates more symptoms). The mean score of each group appears in Table 1. The mean value for the group with

Table 1
Demographic characteristics of the sample divided by group

Variable	High grief symptoms (N = 19)	Low grief symptoms (N = 19)	p
	M (SD) or N (%)	M (SD) or N (%)	
Age	43.53 (12.52)	42.05 (12.97)	.727
Months since death	28.63 (20.15)	38.42 (34.67)	.294
Years of education	12.58 (3.44)	14.2 (2.76)	.115
Gender			.703
Female	14 (73.69%)	15 (78.95%)	
Male	5 (26.31%)	4 (21.05%)	
Relationship with the deceased			.472
Partner	2 (10.51%)	4 (21.05%)	
Child	8 (42.10%)	3 (15.79%)	
Parent	6 (31.58%)	9 (47.37%)	
Sibling	1 (5.26%)	1 (5.26%)	
Other	2 (10.51%)	2 (10.51%)	
Nature of the loss			.239
Illness	11 (57.89)	16 (84.21%)	
Accident	5 (26.31%)	2 (10.51%)	
Suicide	1 (5.26%)	1 (5.26%)	
Murder	2 (10.51%)	0 (0%)	
TRIG - Present feelings	20.47 (4.57)	36.36 (7.09)	<.001
SCL - Depression	20.68 (11.71)	11.78 (8.33)	.011
SCL - Anxiety	12.37 (7.13)	7.16 (9.03)	.056

low grief symptoms is in agreement with the mean value of the test for a population experiencing normal grief (García-García, Landa-Petralanda, Trigueros-Manzano, & Gaminde-Inda, 2005).

Instruments

Intensity of Grief. The Texas Revised Inventory of Grief (TRIG: García-García et al., 2005) is a self-reporting measure consisting of 21 items divided into two subscales (Past Behavior and Present Feelings) that assesses the past and current intensity of emotional symptoms relating to grief. The items are rated on a 5-point Likert scale ranging from 0 to 4. The values of Cronbach's α were .75 and .86 for the Spanish population. In the present study, only the Present Feelings sub-scale was used.

Depression and Anxiety. The Symptom Checklist-90 Revised (SCL-90-R: Derogatis, 2002) is a brief, multifaceted self-reporting questionnaire designed to explore a wide range of psychopathological symptoms. In the current study, the subscales for depression and anxiety were used. The SCL-90-R is validated in Spanish and has normative data (Derogatis, 2002). The reliability of the instrument is correct, with Cronbach's α ranging from .81 to .90.

Flexibility. The Trail Making Test (TMT) from the assessment battery of the Delis-Kaplan EF System (Delis, Kaplan, & Kramer, 2001) was used. The five parts were administered in order. The total response time for the fourth part was used to calculate the index of flexibility or task switching. In this part, the participants were asked to match numbers and letters while alternating them in sequential order. The total response time of each participant was measured.

Inhibition. The Stroop Task (ST) from the assessment battery of the Delis-Kaplan EF System (Delis et al., 2001) was employed. The third part was used as a measure of inhibition. A sheet containing words (blue, green and red) printed in colors other than those indicated by the words was provided. The participants were asked to name the color of the ink with which the words were printed while ignoring the color indicated by the written word. The total response time of each participant was measured.

Working Memory. The Letter-Number Sequencing (LNS) test from the Weschler Adult Intelligence Scale (WAIS-III: Spanish adaptation by Seisdedos et al., 1999) was used. The task required the experimenter to read a combination of numbers and letters to the participant. The participant repeated the sequence with the numbers in ascending order first and then the letters in alphabetical order. The test was composed of seven elements each of which allowed three attempts and resulted in a score between 0 and 21.

Decision-Making. The computerized version of the IOWA Gambling Task (IGT: Bechara, 2007) was used. Four different decks of cards (A', B', C' and D') were shown to the participant, who freely chose cards from the decks until 100 cards had been selected. While decks A' and B' provided significant winnings, they also provided very large losses. Conversely, decks C' and D' provided smaller winnings and smaller losses. Following previous research, the scores were divided into five blocks of 20 trials each. Traditionally, the first two blocks have been used to assess decision-making under ambiguity, and the last three blocks have been used to assess decision-making under risk (Brand, Heinze, Labudda, & Markowitsch, 2008). The score of each block was obtained by subtracting the number of cards drawn from the disadvantageous decks (A' and B') from the number of cards drawn from the advantageous decks (C' and D').

Procedure

The participants who agreed to participate in the study and satisfied the inclusion criteria took part in a large research project that involved many neuropsychological tasks and self-reported measures. They performed a total of three sessions (one per week) with a duration of one and one-half hours. In the first session, they completed a sheet containing all the self-report questionnaires (TRIG and SCL-90-R). During the third session, they completed the EF tasks: the TMT, the ST, the LNS test and the IGT, which were presented to all the participants in the same order. Following each task, all the participants were given between one and two minutes to debrief before beginning the next task. All the sessions were performed in a quiet place under homogeneous conditions and directed by the same researcher.

This research was approved by the Ethics Committee of Human Research at the University of Granada (Spain). All the participants were informed of the objectives of the study and were given an information sheet. Written informed consent was collected from all the participants before the start of the study.

Data analysis

First, the mean and standard deviation for each task was calculated, and the Kolmogorov-Smirnov test was used to assess the distribution of the scores on each task; the results showed that the TMT, the ST and the LNS test did not have normal distributions. Second, to address the first objective, Student's t-test and the Man-Whitney U test were used to compare the performances of the groups (high and low intensity of grief symptoms) on the EF tasks. Third, to address the second objective, bivariate Pearson correlation analyses were performed for the EF tasks that showed statistically significant differences between groups and emotional variables. Finally, hierarchical regression analyses were performed with the scores on the EF tasks as criterion variables. Due to the limited sample size, in the first block, only those variables that were significantly correlated with the task were included, but in the second block, the score on the "Present Feelings" sub-scale of the TRIG was introduced.

Results

Differences in EF Performance that Depend on Current Symptoms of Grief

The results for each EF task for each group (high and low) are shown in Table 2. No differences were found between the groups for the variables of flexibility, inhibition and working memory. The decision-making component showed significant differences between the groups, $t(36) = 2.72$, $p = .010$ and $d = .88$, which varied with the number of trials in the task. Although for the first two blocks (which tested decision-making under ambiguity), the pattern was the same for both groups, for the remaining three blocks (which tested decision-making under risk), participants in the high symptoms group obtained lower scores than those in the low symptoms group (see Table 2 and Figure 1). Effect sizes were larger for blocks three ($d = .83$), four ($d = .66$) and five ($d = .65$).

Table 2
Mean values, standard deviations and t-test results for each aspect of EF according to the intensity of grief

EF	High symptoms	Low symptoms	U or t	p	Cohen's d
	Mean (SD)	Mean (SD)			
TMT	65.04 (38.17)	49.64 (22.9)	136	.298	.48
ST	54.51 (17.04)	49.28 (10.5)	156	.488	.37
LN	10.42 (3.18)	11.47 (1.59)	114	.138	.42
IGT					
Total	-.95 (21.58)	20.26 (26.17)	2.73	.010	.88
Block 1	-1.68 (4.82)	-1.21 (6.77)	.248	.805	.01
Block 2	-.11 (6.94)	1.89 (7.63)	.842	.405	.27
Block 3	-.42 (9.27)	6.58 (7.57)	2.57	.015	.83
Block 4	.53 (7.85)	6.11 (9.05)	2.03	.050	.66
Block 5	.74 (8.87)	6.89 (10.1)	1.99	.053	.65

Note: TMT = Trial Making Test, ST = Stroop Task, LN = Letter and Number Sequencing and IGT = Iowa Gambling Task
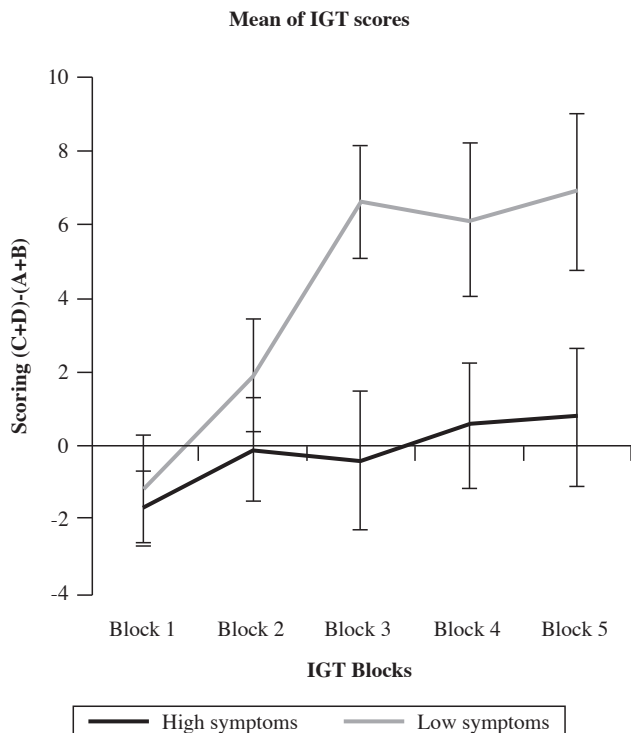

Mean of IGT scores

Figure 1. Mean score on each block of the IGT by group

Role of Grief Symptoms in EF Task Scores

Bivariate correlations showed that anxiety during the first block ($r = .358$, $p = .017$), and current symptoms of grief (blocks three, four, and five) were statistically significant (r ranged from .388 to .454, p values ranging from .009 to .002) and related to performance on the IGT (see Table 3). In addition, the number of years of education had a marginally significant p value for block four ($p = .08$). Hierarchical linear regression analyses that included these three variables were performed for each block of the IGT (see Table 4). The final model was statistically significant for blocks four and five, and marginally

statistically significant for block three ($p = .052$). The anxiety score was statistically significant for block one, which showed that the more anxious participants performed better on the task. Moreover, the TRIG present feelings scores were statistically significant for blocks three and five, where they explained an additional 12 and 13% of the variance, respectively (see Table 4).

Discussion

The aim of this study was to preliminarily assess how the differences in various components of EF depended on the current intensity of symptoms of grief and to study the role that such symptoms played in predicting EF scores. The results suggest that participants with higher symptoms of grief had lower scores on emotional decision-making and that a relevant amount of the variance in blocks three and five was explained by current grief symptoms.

As far as we know, no previous studies have made the distinction between cold and hot EF in participants experiencing grief. Of the four components, emotional decision-making (associated with hot EF) showed differences between groups. No relationship was found between the dimensions of cold EF and symptoms of grief in the current study. It is interesting to note that previous studies have shown neurocognitive alterations in CG, such as attentional bias only when death-related or biographical stimuli were present (Maccallum & Bryant, 2010b).

Our results are in line with previous research on hot EF and emotional processing. There is a great deal of evidence for trouble regulating emotions in participants with CG, including fewer expressions of emotion and unpleasant subjective experiences (Diminich & Bonanno, 2014; Fernández-Alcántara et al., 2016). We observed an IGT profile that was characterized by difficulty learning the contingencies of the task by participants with intense symptoms of grief. While no differences were noted on the two first blocks, participants with higher symptoms of grief performed the worst on the last three. Although the IGT is a complex task with multiple possible interpretations (Turnbull, Bowman, Shanker, & Davies, 2014), it has been accepted that the first 40 trials involve a different process than the last 60 trials do (Brand et al., 2008). Using structural equation modeling, Gansler et al. (2011) determined that the first 40 trials of the IGT were more closely related to measures of attention (decision under ambiguity), while the last 60 were better measures of EF (decision under risk).

The current results seem to point to the possibility of grief symptoms influencing decision-making under risk but not under ambiguity. Previous studies have indicated that anxiety influences

Table 3
Correlations between sociodemographic and emotional variables and the blocks of the IGT

	Gender	Age	Years of education	Anxiety	Depression	TRIG - Present feelings
Block 1	-.082	.172	-.029	.358*	.183	.004
Block 2	.152	-.069	.169	-.080	-.087	.148
Block 3	-.032	-.049	.120	-.206	.037	.408**
Block 4	-.107	-.041	.263†	-.261	-.171	.388**
Block 5	-.018	-.115	.191	-.247	-.034	.454**

Note: † p<.10, * p<0.05; ** p<0.01

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Table 4
Hierarchical regression models for the five blocks of the IGT

Criterion variable	Final model		Block 1			Block 2			
	F	R²	Variable	St. β	t	ΔR²	Variable	St. β	t
IGT Block 1	2.26†	.145	Education	.035	.236		Education	-.013	-.083
			Anxiety	.364	2.46*		Anxiety	.403	2.59*
						.016	TRIG	.142	.855
IGT Block 2	.518	.037	Education	.160	1.027		Education	.130	.773
			Anxiety	-.051	-.329		Anxiety	-.027	-.167
						.006	TRIG	.089	.504
IGT Block 3	2.81*	.174	Education	.087	.561		Education	-.049	-.314
			Anxiety	-.191	-1.234		Anxiety	-.083	-.545
						.124*	TRIG	.399	2.45*
IGT Block 4	2.99*	.183	Education	.224	1.500		Education	.124	.800
			Anxiety	-.222	-1.490		Anxiety	-.143	-.944
						.067†	TRIG	.292	1.80†
IGT Block 5	3.61*	.217	Education	.153	.993		Education	.028	.184
			Anxiety	-.220	-1.433		Anxiety	-.106	-.704
						.134*	TRIG	.409	2.58*

Note: †p<.10, * p<0.05; ** p<0.01, St. β = Standardized β

decision-making (Zhang, Wang, Zhu, Yu, & Chen, 2015). Current symptoms of grief seemed to also influence this process, explaining a substantial amount of variance. Recent research has pointed to alterations in the reward system during CG. The levels of yearning have been associated with hyperactivation of the nucleus *accumbens* during CG (O'Connor et al., 2008).

One possible explanation of their emotional decision-making performance is that a participant experiencing intense grief also experiences a dysregulation of the reward system that is generalized rather than specific to the death or biographical stimulus. This is in line with previous studies that point to an unpleasant emotional experience in participants with CG when they are exposed to positive and negative stimuli (Fernández-Alcántara et al., 2016). In addition, specific symptoms of CG, such as emotional numbness, may impede the adequate interpretation of current body signals during the IGT, with the consequence of insensitivity to punishment (e.g., a preference for decks A and B despite the consistent loss of an important amount of money) during the task. In addition, previous research has reported obstacles for future reward processing in participants with CG (Maccallum & Bonanno, 2015).

The results of the current study have remarkable clinical implications. Although the analysis performed did not allow causal evidence to be obtained, the question of whether the disturbance to emotional decision-making is a cause or a consequence of CG was raised. Scientific evidence suggests that CG is triggered by a specific event (the death of a loved one) in people who previously functioned adaptively or normally (Bonanno & Diminich, 2013). When a loss cannot be integrated into the biographical self, the outcome is CG (Maccallum & Bryant, 2013). In that sense, EF may be an important variable to consider in optimizing clinical interventions (for example, by advising against quick emotional decisions during times of intense grief). Nevertheless, it is also possible that those who have poor hot EF may have more problems when facing the death of a loved one.

A number of questions remain unanswered due to the preliminary nature of this study. Further studies using a wide range of specific tasks designed to assess emotional decision-making under risk and under ambiguity are needed to test whether the bias in this population is exclusively focused on one of these decision-making processes. The role of reminders of the loss in decision-making processes also needs to be clarified. Future studies, including experimental manipulations of EF, are needed to clarify its role in complex grief processes.

This research has a number of limitations and strengths. The sample size was small, but effect sizes, which are more independent of the sample size, were reported. Four components of EF were assessed, but it is necessary to replicate these findings using other neuropsychological tasks. The level of anxiety was used as a confounding variable during the regression analyses, and the intensity of grief during the assessment was evaluated. Further research with a larger sample is needed to control the influence of other variables and enable differentiation between CG with and without depression or anxiety. Finally, secondary factors that were not controlled in this preliminary research, such as reading level, motivation, fatigue and general intelligence or IQ, need to be addressed in future neuropsychological studies.

In conclusion, higher actual symptoms of grief were related to poor emotional decision-making performance in the last blocks of the IGT. In addition, grief symptoms and anxiety explained a substantial part of the variance in the IGT scores.

Acknowledgments

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