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## Predicting social problem solving using personality traits

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### ABSTRACT

This study examined the relations between personality traits and social problem-solving ability. Personality was measured by the Eysenck Personality Questionnaire-Revised, the NEO Five-Factor Inventory, and the Positive and Negative Affect Schedule. Social problem-solving ability was assessed by the Social Problem-Solving Inventory-Revised, which measures five different dimensions of problem-solving ability. Results of stepwise multivariate multiple regression analyses showed that neuroticism was the strongest predictor of any single problem-solving dimension (negative problem orientation), whereas conscientiousness was the most consistent predictor across all five dimensions. Conscientiousness, openness, and positive affectivity predicted higher problem-solving ability, whereas neuroticism predicted lower ability. Squared multiple correlations for SPS dimensions range from 58% for negative problem orientation to just 19% for rational problem solving.

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### 1. Introduction

Advances in the conceptualization of personality dimensions in recent years have led to a renewed research interest in the relations between personality traits and adjustment (Miller, 2003; Ozer & Benet-Martínez, 2006; Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007; Wiggins, 1996). A key issue is what cognitive and behavioral mechanisms mediate the relations between higher-order personality dimensions and specific adaptational outcomes (Cantor, 1990). It has been suggested that one of the most important mediator variables might be *coping* (Carver & Connor-Smith, 2010; Connor-Smith & Flachsbart, 2007; Matthews, Saklofske, Costa, Deary, & Zeidner, 1998), which has been defined as the cognitive and behavioral activities by which an individual attempts to manage a stressful situation and/or the emotions that it generates (Lazarus & Folkman, 1984). According to Baron and Kenny (1986), in order to establish mediation, the independent variable (e.g., personality) must be significantly related to the hypothesized mediator (e.g., coping). Hence, before examining coping as a possible mediator between personality and adjustment or psychopathology, a reasonable first step is to identify *what* particular personality dimensions are associated with *what* coping activities.

Arguably, the most important coping strategy for adjustment might be *social problem solving* (D'Zurilla & Goldfried, 1971;

D'Zurilla & Nezu, 1982, 1999), which refers to the general coping strategy by which a person attempts to develop effective coping responses for specific problematic situations in everyday living.

Most of the research on this field is based on the model that was originally introduced by D'Zurilla and Goldfried (1971) and later expanded and refined by D'Zurilla and Nezu (1982, 1999), D'Zurilla, Nezu, and Maydeu-Olivares (2002), and Maydeu-Olivares and D'Zurilla (1996). A major assumption of this model is that problem-solving outcomes in the real world are largely determined by two general, partially independent processes: (1) problem orientation and (2) problem-solving style. *Problem orientation* is a cognitive-emotional process that primarily serves a motivational function in social problem solving. *Problem-solving style*, on the other hand, consists of the cognitive and behavioral activities by which a person attempts to understand problems and find effective "solutions" or coping responses. Thus, D'Zurilla et al. (2002) identified a five-dimensional social problem solving model consisting of two different problem orientation dimensions (positive and negative) and three different problem-solving styles (rational problem solving, impulsivity/carelessness style, and avoidance style).

*Positive problem orientation* involves the general disposition to (a) appraise a problem as a "challenge" (i.e., opportunity for benefit or gain), (b) believe that problems are solvable, and (c) believe in one's personal ability to solve problems successfully. In contrast, *negative problem orientation* involves the general tendency to (a) view a problem as a significant threat to well-being, (b) doubt one's personal ability to solve problems successfully, and (c) easily become frustrated and upset when confronted with problems in

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living. On the other hand, *rational problem solving* is defined as the rational, deliberate, and systematic application of effective problem-solving skills. *Impulsivity/carelessness style* is characterized by active attempts to apply problem-solving strategies and techniques, but these attempts are narrow, impulsive, careless, hurried, and incomplete. Finally, *avoidance style* is characterized by procrastination, passivity or inaction, and dependency.

The aim of the present research was to determine to which extent individual differences on each of the five dimensions of social problem-solving ability are related to personality traits in a large sample of undergraduate college students. The study focused on two well-established personality models: the PEN model (Eysenck, Eysenck, & Barrett, 1985), and the five-factor model (FFM; Costa & McCrae, 1992).

Because of the well-established link between certain personality dimensions and emotionality, specifically, neuroticism and negative emotionality, and extraversion and positive emotionality (Eysenck & Eysenck, 1975; Tellegen, 1985; Watson & Clark, 1992), we also included a measure of positive and negative trait affectivity in this study, namely, the Positive and Negative Affect Schedule (PANAS, Watson, Clark, & Tellegen, 1988).

To the authors' knowledge, this is the first large sample, comprehensive study of the relations between these major personality models and social problem solving. Although a number of previous studies have explored the relations between different personality or affectivity measures and specific social problem-solving measures (e.g., Burns & D'Zurilla, 1999; Chang & D'Zurilla, 1996; Elliott, Herrick, MacNair, & Harkins, 1994; Elliott, Shewchuk, Richeson, Pickelman, & Weaver Franklin, 1996; Jaffee & D'Zurilla, 2009; McMurrin, Duggan, Christopher, & Huband, 2007; McMurrin, Egan, Blair, & Richardson, 2001; Watson & Hubbard, 1996), only one study has examined the five problem-solving dimensions measured by the SPSI-R (McMurrin et al., 2001).

McMurrin et al. (2001) examined the relations between the five NEO-FFI personality factors and the five SPSI-R dimensions in a sample of 52 mentally-disordered offenders. The personality factor that was found to be most strongly associated with social problem-solving ability was neuroticism. This personality dimension was found to be positively related to all three dysfunctional problem-solving dimensions (negative problem orientation, impulsivity/carelessness style, and avoidance style) and negatively related to both constructive dimensions (positive problem orientation and rational problem solving).

The present study examined two major hypotheses. First, based on conceptual similarities between the personality, affectivity, and problem-solving constructs focused on in this study, as well as the results of previous research (e.g., McMurrin et al., 2001; Watson & Hubbard, 1996), we predicted that personality and affectivity will account for a significant amount of variance in social problem solving ability. More specifically, we expected that the "positive" personality and affectivity dimensions (i.e., extraversion, openness, conscientiousness, and positive affectivity) would predict more constructive problem solving (i.e., positive problem orientation and rational problem solving) and less dysfunctional problem solving (i.e., negative problem orientation, impulsivity/carelessness style, and avoidance style), whereas the "negative" personality and affectivity dimensions (i.e., neuroticism, psychoticism, and negative affectivity) would predict more dysfunctional problem solving and less constructive problem solving. Second, based on the assumption that the cognitive and behavioral variables in neuroticism and extraversion are likely to influence problem solving independent of the effects of affectivity, we predicted that neuroticism and extraversion will each account for a significant amount of variance in social problem-solving ability even after controlling for negative and positive affectivity.

## 2. Methods

### 2.1. Participants

The participants in this study were 650 undergraduate college students (104 men, 541 women, five gender missing) enrolled in an introductory psychology course at the University of Barcelona, Spain. The mean age was 20.41 years (std = 4.20).

### 2.2. Measures

The participants completed a self-report test battery consisting of the *Social Problem Solving Inventory-Revised* (SPSI-R, D'Zurilla et al., 2002), the *Eysenck Personality Questionnaire-Revised* (EPQ-R, Eysenck & Eysenck, 1975; Eysenck et al., 1985), the *NEO Five-Factor Inventory* (NEO-FFI, Costa & McCrae, 1992) and the *Positive and Negative Affect Schedule* (PANAS, Watson et al., 1988). We used existing Spanish adaptations of the SPSI-R (Maydeu-Olivares, Rodríguez-Fornells, Gómez-Benito, & D'Zurilla, 2000) and the EPQ-R (Aguilar, Tous, & Andrés-Pueyo, 1990). Spanish adaptations of the NEO-FFI and PANAS were developed for this study using the back-translation method, a judgmental method for valid cross-cultural comparisons (Berry, 1980).

#### 2.2.1. Social Problem-Solving Inventory-Revised (SPSI-R)

The SPSI-R consists of five major scales that measure the five different social problem-solving dimensions described above. These scales are positive problem orientation (PPO), negative problem orientation (NPO), rational problem solving (RPS), impulsivity/carelessness style (ICS) and avoidance style (AS). The coefficient alphas for these five scales in the present sample are .68 (PPO), .88 (NPO), .91 (RPS), .83 (ICS) and .90 (AS). Further evidence supporting the reliability and validity of the SPSI-R is reported in D'Zurilla et al. (2002).

#### 2.2.2. Eysenck Personality Questionnaire-Revised (EPQ-R)

The EPQ-R consists of the following three scales: extraversion (E), neuroticism (N), and psychoticism (P). The coefficient alphas for the EPQ-R scales in the present sample are .80 (E), .83 (N), and .67 (P). Additional data supporting the reliability and validity of the EPQ-R are reported in Eysenck et al. (1985).

#### 2.2.3. NEO Five-Factor Inventory (NEO-FFI)

The NEO-FFI is a short-form version of the revised NEO Personality Inventory (NEO-PI-R; Costa & McCrae, 1992). The NEO-FFI consists of the following five scales: neuroticism (N), extraversion (E), openness (O), agreeableness (A), and conscientiousness (C). High correlations have been reported between the NEO-FFI scales and corresponding NEO-PI-R scales (ranging from .77 to .94 across various samples). Coefficient alphas for the NEO-FFI scales in the present sample are .78 (N), .86 (E), .65 (O), .60 (A), and .81 (C). Additional evidence for the reliability and validity of the NEO-FFI is reported in Costa and McCrae (1992).

#### 2.2.4. Positive and Negative Affect Schedule (PANAS)

The PANAS consists of two scales that measure positive affectivity (PA) and negative affectivity (NA). By modifying the instructions, the PANAS can be used to measure either state affect or trait affectivity. The present study used the trait instructions (participants report how they *generally* feel). The coefficient alphas in the present sample are .73 for PA and .84 for NA. Further support for the reliability and validity of the PANAS is reported in Watson et al. (1988).

**Table 1**  
Correlations between the personality, affectivity and problem-solving measures.

	EPQ-E	EPQ-N	EPQ-P	NEO-N	NEO-E	NEO-O	NEO-A	NEO-C	PA	NA
PPO	0.26**	-0.31**	0.06	-0.38**	0.32**	0.22**	0.00	0.32**	0.45**	-0.23**
NPO	-0.26**	0.61**	-0.03	0.70**	-0.33**	-0.09*	-0.09*	-0.37**	-0.37**	0.48**
RPS	0.05	-0.06	-0.09*	-0.08*	0.10*	0.27**	0.04	0.34**	0.29**	-0.03
ICS	0.16**	0.18**	0.20**	0.18**	0.05	-0.17**	-0.17**	-0.35**	-0.07	0.14**
AS	-0.18**	0.36**	0.08*	0.43**	-0.24**	-0.17**	-0.13**	-0.43**	-0.32**	0.30**

Notes. N = 650; SPSI-R scales: PPO = positive problem orientation, NPO = negative problem orientation, RPS = rational problem solving, ICS = impulsivity/carelessness style, AS = avoidance style; EPQ-R scales: E = extraversion, N = neuroticism, P = psychoticism; NEO-FFI scales: E = extraversion, N = neuroticism, O = openness to experience, A = agreeableness, C = conscientiousness; PANAS scales: PA = positive affect, NA = negative affect.

\* p < .05.  
\*\* p < .01.

**3. Results**

All social problem-solving dimensions were significantly inter-correlated. There were also significant relationships among some of the personality and affectivity dimensions. Bivariate correlations between the different personality and affectivity dimensions and the five problem-solving dimensions are presented in Table 1. As the table shows, all of the personality and affectivity dimensions except psychoticism and agreeableness were found to be significantly related to at least four problem-solving dimensions, although the magnitude of some of the correlations is quite low. Three personality dimensions, NEO neuroticism, conscientiousness, and openness are related to all five problem-solving dimensions.

In general, as predicted, the “positive” personality and affectivity dimensions (extraversion, openness, conscientiousness, and positive affectivity) tend to be positively related to constructive problem solving and negatively related to dysfunctional problem solving, whereas the “negative” dimensions (neuroticism, psychoticism, and negative affectivity) tend to be positively related to dysfunctional problem solving and negatively related to constructive problem solving.

Because several personality and affectivity dimensions are significantly related, some of the low, albeit significant, correlations with the problem-solving dimensions in Table 1 may be basically spurious, reflecting the indirect influences of stronger, correlated predictor variables. Hence, in order to determine what personality or affectivity dimensions are the most important independent or unique predictors of social problem solving, we used *stepwise multivariate multiple regression* to predict the five different problem-solving dimensions from, (a) the EPQ-R scales, (b) the NEO-FFI scales, (c) the PANAS scales, and (d) all three sets of predictor variables combined. LISREL (Jöreskog & Sörbom, 2001) was used to perform these analyses with a GLS fitting function and  $\alpha = 0.01$  as criterion for variable addition and removal. Because of the multiple analyses on the same problem-solving measures, we adopted the more conservative significance level of  $\alpha = 0.01$  for these analyses rather than the customary  $\alpha = 0.05$ . The squared multiple

**Table 2**  
Squared multiple correlations predicting problem solving from the personality and affectivity measures.

	EPQ-R	NEO	PANAS	All
PPO	0.11	0.28	0.24	0.32
NPO	0.38	0.55	0.36	0.58
RPS	0.01	0.18	0.06	0.19
ICS	0.11	0.21	0.02	0.21
AS	0.14	0.32	0.18	0.33

Notes. SPSI-R scales: PPO = positive problem orientation, NPO = negative problem orientation; RPS = rational problem solving, ICS = impulsivity/carelessness style, AS = avoidance style.

correlations obtained for each analysis are shown in Table 2 and the standardized regression coefficients are presented in Table 3.

**3.1. Predicting Problem-Solving Ability from the EPQ-R**

The results of the stepwise multivariate multiple regression analysis suggest that four regression coefficients are not significant at the chosen alpha level. An overall chi-square test for these restrictions yields  $\chi^2(4) = 5.23, p = 0.26$ . Thus, a regression model with these restrictions cannot be rejected. As expected from the correlations reported in Table 1, the EPQ-R scales were found to substantially predict problem-solving ability, although as Table 2

**Table 3**  
Standardized regression coefficients obtained by stepwise multivariate multiple regression of the personality and affectivity measures on the problem-solving measures.

EPQ-R as predictor	EPQ-E	EPQ-N	EPQ-P
PPO	0.18	-0.24	-
NPO	-0.13	0.57	-
RPS	-	-	-0.12
ICS	0.22	0.19	0.18
AS	-0.11	0.32	0.11

  

NEO-FFI as predictor	NEO-N	NEO-E	NEO-O	NEO-A	NEO-C
PPO	-0.29	0.17	0.20	-0.09	0.23
NPO	0.63	-0.07	-0.09	-	-0.20
RPS	-	-	0.24	-	0.35
ICS	0.15	0.21	-0.15	-0.14	-0.34
AS	0.35	-	-0.13	-	-0.35

  

PANAS as predictor	PA	NA
PPO	0.44	-0.22
NPO	-0.36	0.48
RPS	0.25	-
ICS	-	0.13
AS	-0.30	0.30

EPQ-R, NEO-FFI and PANAS as joint predictors										
	EPQ-E	EPQ-N	EPQ-P	NEO-N	NEO-E	NEO-O	NEO-A	NEO-C	PA	NA
PPO	-	-	0.08	-0.27	-	0.08	-	0.19	0.30	-
NPO	-	0.13	-	0.52	-	-	-	-0.17	-0.16	-
RPS	-	-	-	-	-	0.20	-	0.30	0.14	-
ICS	0.20	-	0.08	0.17	-	-0.15	-0.09	-0.29	-	-
AS	-	-	-	0.31	-	-	-0.09	-0.31	-0.16	-

Notes. SPSI-R scales: PPO = positive problem orientation, NPO = negative problem orientation, RPS = rational problem solving, ICS = impulsivity/carelessness style, AS = avoidance style; EPQ-R scales: E = extraversion, N = neuroticism, P = psychoticism; NEO-FFI scales: E = extraversion, N = neuroticism, O = openness, A = agreeableness, C = conscientiousness; PANAS scales: PA = positive affect, NA = negative affect.

All regression coefficients are significant  $p < 0.01$ .

shows, the amount of variance accounted for in each of the five problem-solving dimensions ranges from a high of 38% (negative problem orientation) to a low of only 1% (rational problem solving). As expected, the strongest EPQ-R predictor is clearly neuroticism (see Table 3). Even after controlling for the other two personality dimensions, neuroticism and psychoticism were each found to be positively related to dysfunctional problem solving and negatively related to constructive problem solving. In addition, extraversion was found to be positively related to constructive problem solving and negatively related to dysfunctional problem solving. However, one specific exception to the predicted pattern is the significant relationship between extraversion and impulsivity/carelessness style, which was found to be positive rather than negative.

### 3.2. Predicting Problem-Solving Ability from the NEO-FFI

In the second analysis, six regression coefficients were found to be non-significant at the chosen alpha level. An overall chi-square test for these restrictions yields  $\chi^2(6) = 11.84, p = 0.06$ . The amount of variance accounted for in the problem-solving dimensions ranges from a high of 55% (negative problem orientation) to a low of 18% (rational problem solving). When compared to the EPQ-R, the NEO-FFI enhances considerably the prediction of the five problem-solving dimensions. All five personality dimensions measured by the NEO-FFI were found to be unique predictors of problem solving (see Table 3). While neuroticism is the strongest predictor of any single problem-solving dimension (negative problem orientation), conscientiousness is the strongest consistent predictor across all five dimensions. Although the relationships are not as strong, openness was also found to be a significant predictor of all five problem-solving dimensions. As expected, after controlling for the other personality dimensions, neuroticism was found to be positively related to dysfunctional problem solving and negatively related to constructive problem solving. Moreover, conscientiousness, openness, and extraversion were each found to be positively related to constructive problem solving and negatively related to dysfunctional problem solving. Consistent with the findings for EPQ extraversion and contrary to the predicted pattern, NEO extraversion was also found to be positively related to impulsivity/carelessness style.

### 3.3. Predicting Problem-Solving Ability from the PANAS

In the third analysis, only two regression coefficients were found to be non-significant at the chosen alpha level. An overall chi-square test for these restrictions yields  $\chi^2(2) = 3.61, p = 0.16$ . Problem-solving ability was also found to be substantially predicted by the PANAS scales. As Table 2 shows, the amount of variance accounted for in the problem-solving dimensions ranges from a high of 36% (negative problem orientation) to a low of 2% (impulsivity/carelessness style). Overall, the predictive power of the PANAS is slightly greater than that of the EPQ-R, but much less than the power for the NEO-FFI. Positive affectivity and negative activity appear to be equally strong unique predictors (see Table 3). As expected, when the other affectivity dimension was controlled, positive affectivity was found to be positively related to constructive problem solving and negatively related to dysfunctional problem solving, whereas the reverse was true for negative affectivity.

### 3.4. Predicting Problem-Solving Ability from the EPQ-R, NEO-FFI, and PANAS Jointly

As expected from the results of the first three analyses, a model consisting of the EPQ-R, NEO-FFI, and PANAS was found to be a

strong predictor of problem-solving ability. As Table 2 shows, the amount of variance accounted for in the problem-solving dimensions ranges from a high of 58% (negative problem orientation) to a low of 18% (rational problem solving). Comparing the predictive power of this combined model to that of each of its three components alone, it is clear that this model enhances the prediction of problem solving considerably when compared to either the EPQ-R or the PANAS alone, but *not* when compared to the NEO-FFI alone. Interestingly, when all three inventories are used to predict social problem solving, a large number of regression paths (28) are non-significant. A regression model with these restrictions cannot be rejected  $\chi^2(28) = 40.29, p = 0.06$ . Thus, these three sets of predictors substantially overlap. Furthermore, the standardized regression coefficients obtained by this analysis enable us to determine what personality and affectivity dimensions are the best *independent* or unique predictors of problem-solving dimensions when all other personality and affectivity dimensions are controlled.

As Table 3 shows, the best independent predictors of problem solving appear to be conscientiousness, NEO neuroticism, positive affectivity, and openness, in that order. Although NEO neuroticism was found to be the strongest unique predictor of any single problem-solving dimension (negative problem orientation), conscientiousness was the only dimension that was found to be a unique predictor of all five problem-solving dimensions. It is noteworthy that the positive relationship between EPQ extraversion and impulsivity/carelessness style remained significant when all other personality and affectivity dimensions were controlled, whereas the relationship between NEO extraversion and impulsivity/carelessness style became non-significant. It is also noteworthy that after all other personality and affectivity dimensions were controlled, all of the significant relations between NEO neuroticism and problem solving remained significant, whereas all of the relations between negative affectivity and problem solving became non-significant. On the other hand, except for the unexpected positive relationship between EPQ extraversion and impulsivity/carelessness style, all of the other significant relations between extraversion and problem solving became non-significant, whereas all of the relations between positive affectivity and problem solving remained significant.

## 4. Discussion

In general, the results of this study supported our two hypotheses. Except for a few specific findings, strong support was found for our first hypothesis, that personality and affectivity would account for a significant amount of variance in social problem-solving ability. Of the three personality and affectivity models examined in this study, the best predictor of social problem-solving ability was found to be the NEO five-factor personality model (NEO-FFI). Considering each of the five problem-solving dimensions, the largest amount of variance accounted for by this model was in negative problem orientation (55%), and the least amount was in rational problem solving (18%). Based on the results for the combined predictor model (EPQ-R, NEO-FFI, PANAS), the strongest unique predictor of any single problem-solving dimension was found to be NEO neuroticism, which accounted for about 27% of the variance in negative problem orientation after controlling for all of the other personality and affectivity dimensions. This finding is consistent with previous findings (McMurrin et al., 2001). However, in contrast with the results reported by McMurrin et al., the most *consistent* unique predictor of social problem-solving ability in the present sample was conscientiousness, which was the only personality or affectivity dimension that was found to be significantly related to all five problem-solving dimensions after controlling for all of the other predictor variables.

Considering the combined predictor model, personality and affectivity was found to account for more variance in problem

orientation than in the problem-solving styles. This model accounted for 58% of the variance in negative problem orientation and 32% of the variance in positive problem orientation. Looking at the findings more specifically, however, NEO neuroticism and positive affectivity were found to be more strongly related to problem orientation than the problem-solving styles, whereas the reverse was true for conscientiousness and openness. Of the three problem-solving styles, rational problem solving (i.e., effective problem-solving skills) was most strongly related to conscientiousness and openness. This is not surprising, as the emotionality in neuroticism and positive affectivity are clearly more conceptually similar to problem orientation than the problem-solving styles. Individuals who score high on conscientiousness and openness are described as persistent, industrious, organized, and open to varied experiences and ideas, which appear to be important characteristics for rational problem solving.

As expected, after controlling for all of the other personality and affectivity variables, conscientiousness, openness, and positive affectivity significantly predicted *more* constructive problem solving and *less* dysfunctional problem solving. In addition, neuroticism and psychoticism significantly predicted *more* dysfunctional problem solving, but only NEO neuroticism also predicted *less* constructive problem solving. One notable exception to the predicted pattern was the significant *positive* relationship that was found between EPQ extraversion and impulsivity/carelessness style. It appears that individuals with a more extraverted personality style also tend to have a more impulsive/careless problem-solving style. This finding is not surprising when one considers the fact that one of the characteristics of EPQ extraversion is a general tendency to be impulsive.

Regarding our second hypothesis, that neuroticism and extraversion would each significantly predict problem solving even after controlling for negative and positive affectivity, strong support was found for neuroticism but only weak support was found for extraversion. Overall, results suggest that the significant relations that have been found between negative affectivity and dysfunctional problem solving (e.g., Chang & D'Zurilla, 1996; Elliott et al., 1994, 1996) can be accounted for by neuroticism, and that the significant relations that have been found between extraversion and constructive problem solving (McMurrin et al., 2001; Watson & Hubbard, 1996) can be accounted for by positive affectivity. This is of particular importance given the relationships that have been established between personality disorders and social problem solving (McMurrin et al., 2001) and that problem solving might be one of the key issues to address in the treatment of personality-disordered people (Crawford, 2007).

In closing, the results of this study suggest individuals who are generally more conscientious (persistent, industrious, organized), more open (receptive toward varied experiences and ideas), and more likely to experience positive emotions are also more likely to possess good problem-solving ability, whereas individuals who have more neurotic characteristics (worry, anxiety, moodiness, depression) are more likely to have poor problem-solving ability. The results of this study contribute to a better understanding of the problem-solving activities that are associated with the personality and affectivity dimensions. Specifically, they suggest that conscientiousness, openness, and positive affectivity may predict more effective problem solving and, consequently, better adjustment, whereas neuroticism is likely to predict more *ineffective* problem solving and, therefore, more maladjustment and psychopathology. Future research is needed to test these predictions.

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