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Development of Indirect Measures of Conscientiousness: Combining a Facets Approach and Network Analysis

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Abstract: Because indirect measures of personality self-concepts such as the Implicit Association Test (IAT) allow tapping into automatic processes, they can offer advantages over self-report measures. However, prior investigations have led to mixed results regarding the validity of indirect measures of conscientiousness. We suggest that these results might be due to a failure to consider the different facets of conscientiousness. These facets are of crucial importance because they are associated differentially with other psychobiological constructs and they are also characterized by different mechanisms. Therefore, focusing on facets while developing indirect measures of conscientiousness may improve the validity of such measures. In Study 1, we conducted a psycholexical investigation to develop one IAT for each conscientiousness facet. In Study 2, we examined the convergent and discriminant validities of each facet IAT in relation to self-report measures, peer-report measures and self-report behavioural indicators, and we investigated differential associations of the conscientiousness facets with working memory capacity and self-control. We employed network analysis as a novel approach to elucidate differential relationships involving personality facets. The results corroborated the convergent and discriminant validity of the conscientiousness facet IATs with self-reports and showed that the conscientiousness facets were differentially associated with working memory capacity and with self-control. Copyright © 2015 European Association of Personality Psychology

Key words: Implicit Association Test; conscientiousness facets; working memory; self-control; network analysis

Conscientiousness is a broad trait included in most taxonomies of personality, such as the Big Five (Goldberg, 1993; John & Srivastava, 1999) and HEXACO models (Ashton et al., 2006; Ashton, Lee, Perugini, et al., 2004; Lee & Ashton, 2008; Saucier, 2009). Conscientiousness is defined as the 'socially prescribed impulse control that facilitates task- and goal-directed behavior, such as thinking before acting, delaying gratification, following norms and rules, and planning, organizing and prioritizing tasks' (John & Srivastava, 1999, p. 121). Several studies have investigated the lower-level facet structure of conscientiousness using self-report measures (Jackson et al., 2010; MacCann, Duckworth & Roberts, 2009; Peabody & De Raad, 2002; Perugini & Gallucci, 1997; Roberts, Bogg, Walton, Chernyshenko & Stark, 2004; Roberts, Chernyshenko, Stark & Goldberg, 2005). Up to 10 different facets have been identified in different studies (cf. Roberts, Lejuez, Krueger, Richards & Hill, 2014). Among these, four main facets have been recovered in a consistent way, albeit with slightly different labels, and are industriousness, impulse control, orderliness and responsibility[1] (e.g. Roberts et al., 2014, Table 1).

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[1]Responsibility has been also considered as a blend of conscientiousness and agreeableness (e.g. Roberts et al., 2004, 2014).

It is important to notice that, at this finer-grained level of personality structure, consensus among scholars is less pronounced, and which of the facets is included in a questionnaire depends largely on theoretical considerations and inclinations of the authors. For example, the NEO Personality Inventory Revised (NEO-PI-R; Costa & McCrae, 1992) includes six facets of conscientiousness. However, when analysed together with facets of conscientiousness taken from other main personality questionnaires, these six facets of the NEO-PI-R tap into only three of the main general facets of conscientiousness: Order loads on an orderliness factor; deliberation loads on impulse control; and dutifulness, achievement striving, competence and self-discipline load on industriousness (Roberts et al., 2005). Therefore, among the main four facets, industriousness is overrepresented in the NEO-PI-R, whereas responsibility is not represented at all. Similarly, a theoretical analysis of the four conscientiousness facets of the HEXACO Personality Inventory (HEXACO-PI; Lee & Ashton, 2004) reveals that none of them reflects the facet of responsibility. As we will argue later, these choices have important ramifications for the evaluation of conscientiousness research.

In terms of construct assessment and behavioural prediction, conscientiousness has been widely investigated. For example, on the basis of analyses of self-reports, conscientiousness has been shown to be a consistent predictor of

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several important life outcomes such as health (Bogg & Roberts, 2004; Friedman & Kern, 2014; Roberts, Walton & Bogg, 2005), longevity (Kern & Friedman, 2008), academic performance (Poropat, 2009) and job performance (Barrick & Mount, 1991).

In addition to self-reports, indirect measures[2] have been developed to assess personality constructs such as conscientiousness, consistent with many theoretical models postulating that human behaviour is influenced by deliberative and automatic processes (Back, Schmukle & Egloff, 2009; Deutsch & Strack, 2010; Evans, 2008; Gawronski & Bodenhausen, 2007; Gawronski, Sherman & Trope, 2014; Strack & Deutsch, 2004). In the general domain of personality, as well as in other domains, the Implicit Association Test (IAT; Greenwald, McGhee & Schwartz, 1998) shows acceptable validity and reliability (Bar-Anan & Nosek, 2014; Egloff, Schwerdtfeger & Schmukle, 2005; Greenwald, Poehlman, Uhlmann & Banaji, 2009; Hofmann, Gawronski, Gschwendner, Le & Schmitt, 2005; Nosek, 2007; but see Blanton, Jaccard, Gonzales & Christie, 2006). The IAT has been used to assess the Big Five (Back et al., 2009; Grumm & von Collani, 2007; Schmukle, Back & Egloff, 2008; Steffens & König, 2006) along with specific traits such as shyness (Asendorpf, Banse & Mücke, 2002), anxiety (Egloff & Schmukle, 2002), morality (Perugini & Leone, 2009) and aggressiveness (Richetin, Richardson & Mason, 2010).

In terms of predictive validity, personality IATs can perform better in the prediction of spontaneous and objective behaviours than self-reported behaviours (Asendorpf et al., 2002; Egloff & Schmukle, 2002; Perugini & Leone, 2009; Steffens & König, 2006). In the specific domain of conscientiousness, however, the validity of indirect measures has received mixed empirical support. Indirect measures of conscientiousness showed convergent validity with self-report measures in some studies (Grumm & von Collani, 2007; Schmukle et al., 2008; Steffens & König, 2006), but not others (Back et al., 2009; Vianello, Robusto & Anselmi, 2010). In a similar vein, although some research has demonstrated criterion validity of indirect measures of conscientiousness for particular behavioural criteria (e.g. the performance in a test of attention, Steffens & König, 2006; the number of exams successfully passed, Vianello et al., 2010), an extensive report including several behavioural criteria found no evidence of such validity (Back et al., 2009).

The lack of agreement in prior studies may stem from the fact that each study has measured conscientiousness using different stimuli linked to a different constellation of specific facets. For instance, some authors (e.g. Steffens & König, 2006) primarily assessed industriousness (strong-willed, disciplined, aimless and laid-back), orderliness (i.e. pedantic, organized, chaotic and untidy) and, to a lesser extent, responsibility (dependable and late) and impulse control (disciplined). Others (e.g. Back et al., 2009), however, mainly assessed orderliness (meticulous, neat, fussy, thorough, chaotic and careless) and, to a lesser extent, responsibility (reliable and unreliable), without taking into account industriousness and impulse control.[3] It has been shown that the choice of particular stimuli can substantially influence the IAT effect (Bluemke & Friese, 2006; Govan & Williams, 2004), suggesting that the mixed results could be due to the fact that these researchers assessed different things under the same label.

Prior studies appear to be based on the notion that all measures in the conscientiousness domain are exchangeable, as they might in fact be if they all depended on a single latent variable (Cramer, Waldorp, Van der Maas & Borsboom, 2010). However, research does not support the exchangeability of conscientiousness measures, because the facets of conscientiousness play divergent and specific roles with respect to other traits and behavioural outcomes. Conscientiousness facets have distinguishable precursors in childhood (see Eisenberg, Duckworth, Spinrad & Valiente, 2014, for a review), change differently over the course of life (Jackson et al., 2009; Mõttus et al., 2015; Soto & John, 2012) and have differential relationships with other variables (e.g. Moon, 2001; Perry, Hunter, Witt & Harris, 2010; Ruiz, Pincus & Dickinson, 2003). This has been explained as the effect of narrower personality mechanisms that characterize only some conscientiousness facets, but not the whole dimension (Soto & John, 2012). As a consequence, considering facets improves the prediction of important criteria such as academic performance and health (Ashton, 1998; Bogg & Roberts, 2004; O'Connor & Paunonen, 2007; Paunonen & Ashton, 2001, 2013; Paunonen, 1998), and it results in finer-grained personality profiles (Costa & McCrae, 1995). Here, we argue that studying conscientiousness as if it was a unidimensional latent variable may hinder a thorough understanding of its mechanisms and it may mask important differential roles played by specific facets, especially in relation to indirect measures.

An explanation of the lack of validity of some personality IATs, which do not involve facets, has been put forward by Back and colleagues. According to the Behavior Process Model of Personality (Back et al., 2009), the implicit self-concept of personality consists in a set of connections between the self and other elements of an associative network (e.g. 'me'–'meticulous' or 'me'–'chaotic'), which form as a consequence of the repeated activation of the self together with automatic motivational tendencies (e.g. approach and avoidance) and impulsive behaviours. Back and colleagues noticed that conscientiousness may involve less impulsive processes than other traits (Back et al., 2009, footnote 6); therefore, valid indirect measures of conscientiousness could be difficult to develop. We argue that Back's argument can be qualified by considering conscientiousness facets and their differential relationships with other constructs. Conscientiousness correlates with both promotion and prevention focus (Gorman et al., 2012; Lanaj, Chang & Johnson, 2012), which are motivational tendencies connected to

[2]We use the term indirect and direct rather than implicit and explicit measures in line with the arguments and definitions of De Houwer and Moors (2010).

[3]Two additional stimuli, frivolous and erratic, tapped into more general aspects of conscientiousness that could not be univocally classified in the four-facet structure of conscientiousness.

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approach and avoidance (Higgins, 1997), and from its very origins, it is also strongly connected with impulsivity and self-control (e.g. Eisenberg et al., 2014; MacDonald, 2008; Sharma, Markon & Clark, 2014). However, conscientiousness facets have differential relationships with impulsivity, with facets such as industriousness and impulse control being more clearly related with aspects of impulsivity than the facet orderliness (e.g. Sharma et al., 2014). Because most of the markers used by Back and colleagues in the conscientiousness IAT assessed orderliness and responsibility, their measure may not have reflected aspects of impulsivity, which nonetheless characterize conscientiousness. Back et al. (2009) recognize that their 'results do not definitely exclude the possibility that using other indirect measures of openness and conscientiousness (particularly those highlighting the potentially impulsive aspects of the traits) might help to predict actual behavior' (p. 543). Similarly, we argue that considering facets when developing conscientiousness IATs may result in more valid measures and it may also help to clarify the connections between implicit conscientiousness and impulsivity/self-control. It should be also noticed that even for traits that do not involve impulsive motivational and behavioural tendencies, the additional value of considering indirect measures besides self-reports comes from the lower sensitivity of indirect measures to socially desirable responding and to limits in the introspective ability (e.g. Greenwald et al., 2002, 2009). For instance, self-esteem would not seem to entail clear impulsive motivational and behavioural tendencies; nonetheless, it can be validly assessed using the IAT (Greenwald & Farnham, 2000), and its mechanisms can be conceptualized more clearly if one considers both direct and indirect measures (Zeigler-Hill, 2006).

The main aim of this contribution was (1) developing an indirect assessment of conscientiousness with a focus on its facets and testing its convergent and discriminant validity. Additionally, we investigated the connections between conscientiousness facets and (2) self-control and (3) working memory capacity, with a focus on a more accurate assessment using both direct and indirect measures. We selected self-control and working memory because they are suitable targets to study potential differential aspects of conscientiousness facets. The last aim of the study was to (4) exemplify how network analysis can be used as a method for grasping the complex pattern of relationships among several variables in personality research. In the following, we detail the rationale of each aim.

Aim 1: development of indirect measures of conscientiousness and test of convergent and discriminant validity

In light of the differences in stimuli selection that emerged in previous studies, we performed a first attempt of developing a valid conscientiousness IAT by selecting stimuli that covered different facets of conscientiousness as uniformly as possible. Despite this more systematic selection of stimuli, the IAT did not correlate with self-report measures of conscientiousness (full details about this study can be found in the Supporting Information S1). This motivated us to follow a different approach, based on a more distinct consideration of facets. Instead of developing a single conscientiousness IAT, we decided to develop four different IATs, one for each of the main conscientiousness facets that have been consensually identified in the literature—industriousness, impulse control, orderliness and responsibility.

The development of several IATs to assess specific facets of a personality domain has not been attempted before and poses a new challenge. Because different facets are expected to correlate strongly with each other, inaccuracies in selecting the stimuli for the IATs may result in all of the measures assessing the same superordinate dimension (conscientiousness) without clearly discriminating its facets. Therefore, rather than selecting stimuli on the basis of expert judgment, as usually carried out in IAT studies, we carefully selected the markers to be used as stimuli by means of a dedicated psycholexical study (Ashton & Lee, 2005; De Raad et al., 2014; Goldberg, 1990; Saucier et al., 2014).

The first and most important test of convergent validity was performed with respect to self-report measures. Additionally, we investigated whether the IAT converged also with peer-reports and self-report behavioural indicators connected to specific facets of conscientiousness. Convergent and discriminant validity provides an important indicator of the goodness of indirect measures: A meta-analysis has shown that the IATs that converge with corresponding self-report measures also have better criterion validity (Greenwald, Poehlman, Uhlman & Banaji, 2009), and this seems to be true in particular for self-concept IATs. In the study by Back et al. (2009), the neuroticism and extraversion IATs, which converged with self-reports, also showed predictive and incremental validity, while other IATs that did not converge with self-reports did not predict behaviour. Furthermore, although it is usually assumed that the structure of broad implicit personality traits is akin to the structure that emerges from self-reports (e.g. a Big Five structure, Back et al., 2009; Grumm & von Collani, 2007; Schmukle et al., 2008; Steffens & König, 2006), one cannot exclude that differences between the structure of the explicit and implicit personality may be more pronounced at the level of facets. Convergent and discriminant validity would indicate that the facets assessed at the implicit level correspond to the facets that emerge from self-reports, while absence of convergent and discriminant validity would indicate that some of these facets are difficult to recover at the implicit level.

Aim 2: conscientiousness and self-control

Self-control is the 'exertion of control over the self by the self' (Muraven & Baumeister, 2000, p. 247) that can be enacted by actively resisting temptations (Baumeister, Vohs & Tice, 2007) or by avoiding them (Ent, Baumeister & Tice, 2015). Two main aspects of self-control have been distinguished (De Boer, Van Hooft & Bakker, 2011): Start control is the proactive component of self-control that allows people to initiate desirable behaviour, and stop control is the inhibitory component that obstructs undesirable behaviour. Self-control is one of the most important correlates of

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conscientiousness (de Vries & van Gelder, 2013; Roberts et al., 2014; Tangney, Baumeister & Boone, 2004), and early self-regulatory abilities have a key role in the development of conscientiousness (Eisenberg et al., 2014; MacDonald, 2008; Roberts et al., 2014).

Investigating both conscientiousness and self-control by considering their facets might shed further light on their relationships. On the one hand industriousness and impulse control are closely connected to pursuing goals and resisting temptations, respectively (e.g. Jackson et al., 2010): We hypothesize that industriousness will be more clearly associated with start control, while impulse control should be strongly related with stop control. On the other hand, we expect that the associations between the two aspects of self-control and the other facets of conscientiousness—such as orderliness and responsibility—should be weaker, as these facets do not entail specifically resisting or avoiding temptations.

Aim 3: conscientiousness and working memory capacity

We aimed at investigating the relationships between conscientiousness facets and working memory. Working memory is a multicomponent system that is responsible for maintaining and processing information in the face of distraction (Baddeley & Hitch, 1974; Baddeley, 1992; Conway et al., 2005) and has a high degree of overlap with the concept of executive functioning (McCabe, Roediger, McDaniel, Balota & Hambrick, 2010; Miyake et al., 2000). Previous studies that investigated the relationship between conscientiousness and working memory observed null results (Fleming, Heintzelman & Bartholow, 2015; Murdock, Oddi & Bridgett, 2013; Unsworth et al., 2009; Williams, Suchy & Kraybill, 2010). We suggest that the connections between conscientiousness and working memory could be further elucidated by a systematic consideration of the facets of conscientiousness.

Aim 4: network analysis

The last aim of our work was showing how network analysis can be used for analysing personality data. The network approach has only recently been added to the toolbox of the personality investigator (Cramer et al., 2012; for introductions to network analysis, see for instance de Nooy, Mrvar & Batagelj, 2011; Kolaczyk, 2009; Newman, 2010). A network is a representation of a group of entities and their relationships as a set of nodes and a set of edges that connect the nodes: Networks are used to represent and study many diverse phenomena in several fields of science such as genomics (e.g. Zhang & Horvath, 2005), economics (e.g. Iori, De Masi, Precup, Gabbi & Caldarelli, 2008) and medicine (e.g. Hopkins, 2008). Networks of interactions among affects, cognitions and behaviours have been proposed as an alternative model of personality that does not require latent variables (Cramer et al., 2012): According to the network perspective, the coalescence of observable variables into traits is the consequence of the interactions that take place within such networks (Costantini et al., 2015).

Networks can be used to grasp the complex interplay among several variables in personality studies. In personality networks, nodes typically represent variables such as items or facets, and edges represent their pairwise associations (Costantini et al., 2015; Cramer et al., 2012). The adaptive lasso method (Costantini et al., 2015; Krämer, Schäfer & Boulesteix, 2009) attempts to reconstruct the true population network of partial relationships that gave rise to the observed correlations by constraining some edges to be exactly zero, while maintaining good fit with the data. The computation of an adaptive lasso network is performed in three main steps. First, each variable is regressed on all others using a lasso penalty (Tibshirani, 1996), which causes small regression coefficients to shrink to be exactly zero. At the second stage, each variable is regressed on all others again, this time using an adaptive lasso penalty. The adaptive lasso penalty includes both a lasso penalty and different penalty weights for each coefficient (Zou, 2006), which are computed as the inverse of the regression coefficients computed at the first stage. This results in even more regression coefficients to shrink to zero. The regression coefficients computed at the second stage are then used for reconstructing a matrix of partial correlations, which represents the relationships between any two variables when the other relevant variables are partialled out. Each partial correlation defines an edge in the network; therefore, if an edge connects two nodes, one can conclude that the corresponding constructs are associated and that their association cannot be completely attributed to the other variables, whereas if a link is missing between two variables, they can be considered independent given the others (for further details on the method, see Krämer et al., 2009; for an application to personality, see Costantini et al. 2015). Adaptive lasso networks can be particularly effective for investigating differential relationships characterizing variables that are correlated but distinguishable, such as personality facets (Costantini et al., 2015).

STUDY 1: DEVELOPMENT OF STIMULI FOR IMPLICIT ASSOCIATION TESTS

We adopted a psycholexical approach to select the best markers for each of the four facets to be used in the IATs. Stimuli are often selected based on intuition, without specific empirical evidence of their adequacy to reflect the targeted dimension. This best-guess selection procedure is suboptimal at best, and it may become even more problematic when it is used to differentiate facets of a broader construct. In fact, it carries a considerable risk of identifying sets of stimuli with cross-loadings, because facets should be correlated by definition. A dedicated psycholexical study can therefore represent a major improvement over the quality of the stimuli selected and, thus, of the indirect measures. As far as we are aware, this is the first time that a procedure such as this one has been used to select stimuli for the IAT.

Materials and methods

Participants

One hundred eighty-one participants (76 women, mean age = 22.6 years, $SD = 3.0$) from an Italian university took part in the study.

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Table 1. Factor loadings of the conscientiousness items

	Study 1				Study 2			
Item	IMC	ORD	IND	RES	IMC	ORD	IND	RES
Cauto (cautious)	**.72**	−.06	.09	−.14	**.76**	.08	−.07	−.09
Controllato (controlled)	**.60**	.06	−.07	.06	**.76**	−.02	−.02	−.03
Disciplinato (disciplined)	**.42**	**.21**	−.10	**.31**	**.56**	−.05	**.39**	−.19
Prudente (prudent)	**.72**	.03	.01	.02	**.82**	−.02	−.09	−.09
Riflessivo (reflective)	**.44**	**−.21**	.04	.17	**.45**	**.24**	−.17	.11
Spericolato (reckless)	**−.70**	−.01	−.11	−.02	**−.59**	−.02	−.14	**.31**
Sregolato (profligate)	**−.56**	−.14	−.09	−.16	**−.52**	−.10	**−.27**	**.32**
Impulsivo (impulsive)	**−.68**	.00	−.04	.17	**−.66**	−.13	.19	.02
Istintivo (instinctive)	**−.64**	−.10	.09	.09	**−.78**	.00	.13	.02
Imprudente (imprudent)	**−.64**	**−.22**	.00	.05	**−.73**	**−.22**	.17	−.12
Disordinato (disordered)	.02	**−.84**	.11	.00	.01	**−.89**	.19	−.11
Disorganizzato (disorganized)	**.32**	**−.53**	**−.27**	−.06	.07	**−.60**	−.16	.02
Caotico (chaotic)	−.15	**−.62**	.08	.04	−.12	**−.78**	.17	−.12
Approssimato (haphazard)	−.02	**−.54**	−.05	.05	−.06	**−.31**	**−.43**	**.25**
Impreciso (imprecise)	.19	**−.56**	**−.25**	.04	.04	**−.56**	**−.38**	.14
Preciso (precise)	.10	**.69**	.18	.06	.08	**.61**	**.30**	−.01
Ordinato (ordered)	.06	**.80**	−.05	.04	.03	**.86**	−.15	.12
Organizzato (organized)	−.06	**.61**	**.30**	.15	.07	**.62**	.16	.03
Accurato (careful)	.15	**.49**	**.30**	.11	.04	**.55**	**.33**	−.11
Pignolo (fussy)	.10	**.61**	−.09	−.06	.04	**.68**	.16	−.15
Pigro (lazy)	−.02	.00	**−.69**	−.09	−.01	**−.21**	**−.47**	−.14
Svogliato (unwilling)	.00	−.15	**−.69**	.15	−.01	.10	**−.74**	−.04
Sfaticato (layabout)	−.15	−.11	**−.76**	.02	.05	−.15	**−.64**	−.13
Negligente (negligent)	−.14	.04	**−.47**	−.01	.18	−.04	**−.40**	**−.20**
Incostante (erratic)	−.08	**−.24**	**−.45**	−.15	**−.20**	−.15	**−.48**	**−.22**
Laborioso (hard-working)	.14	−.06	**.61**	−.04	.02	.15	**.58**	.00
Tenace (tenacious)	**−.22**	.00	**.54**	.03	−.14	.06	**.23**	**.40**
Industrioso (industrious)	−.08	−.01	**.40**	−.07	−.12	.24	**.51**	.19
Diligente (diligent)	**.30**	.14	**.45**	**.25**	**.31**	.14	**.63**	**−.26**
Efficace (effective)	−.14	.11	**.48**	.12	−.20	−.18	**.54**	.13
Affidabile (reliable)	.05	−.09	**.21**	**.65**	**.27**	.19	.10	**.54**
Attendibile (dependable)	.02	−.04	−.03	**.46**	.00	−.19	.16	**.27**
Rispettoso (respectful)	**.42**	−.06	−.11	**.42**	**.37**	−.16	.17	.11
Responsabile (responsible)	**.35**	.13	.14	**.37**	**.32**	.16	.15	**.34**
Inaffidabile (unreliable)	.12	−.02	−.01	**−.54**	.01	−.16	−.18	**−.63**
Inattendibile (undependable)	**.43**	−.08	.15	**−.68**	**.29**	−.01	.07	**−.52**
Sconsiderato (rash)	**−.40**	−.11	.01	**−.33**	**−.53**	−.15	.04	**−.25**
Irresponsabile (unaccountable)	−.18	**−.22**	.09	**−.59**	**−.49**	.18	−.03	**−.36**
Indolente (sluggish)	−.07	.09	**−.22**	**−.35**	**−.30**	.06	**−.24**	−.14
Fidato (trustworthy)	—	—	—	—	.17	−.08	.03	**.54**
Correlations among principal components								
ORD	.15				.22			
IND	.06	.29			.11	.22		
RES	.19	.16	.16		.01	−.02	.18	

*Note:*Principal component loadings with oblimin rotation. Loadings larger than .20 are represented in bold. IND, industriousness; ORD, orderliness; IMC, impulse control; RES, responsibility.

Materials

A list of 64 markers of conscientiousness was assembled from previous studies (Caprara & Perugini, 1994; Perugini & Gallucci, 1997; Roberts et al., 2004). These markers were administered in alphabetical order, and participants indicated the extent to which each adjective described them on a scale from 1 (*it does not describe me at all*) to 5 (*it describes me completely*).

Results

Data were ipsatized, that is, standardized within subjects, to remove response tendencies (e.g. Ashton, Lee & Goldberg, 2004; Hofstee, De Raad & Goldberg, 1992), before performing an initial principal component analysis (PCA). The first seven eigenvalues were 12.17, 5.73, 2.91, 2.57, 2.12, 2.02, 1.92 and 1.67; the scree plot therefore suggested a clear elbow after the fourth component. Four components were therefore retained consistent with the aim of this study.[4] The components explained 37% of the total variance, and

[4]Parallel analysis indicated that seven components explained more variance than those extracted from random data (the first random eigenvalues were 2.40, 2.27, 2.17, 2.08, 2.01, 1.94, 1.87 and 1.82). Nonetheless, we retained four factors as our aim was to select best markers for the four facets. Note also that while there is a noticeable gap between the first four eigenvalues and the corresponding first four random eigenvalues, subsequently, the eigenvalues are very close to each other and do not provide unequivocal strong support for a seven-factor solution.

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after an oblimin rotation, they could be interpreted as orderliness, responsibility, industriousness and impulse control. An iterative procedure was then performed to identify the 10 best markers for each of the 4 facets, 5 for the positive and 5 for the negative pole. The main criteria for item selection were as follows: (1) to eliminate adjectives with small loadings (e.g. *pedantic* was dropped for this reason); (2) to avoid negating adjectives whenever possible (e.g. *incautious* was dropped for this reason); and (3) to eliminate items with cross-loadings (e.g. *conscientious* was dropped for this reason).

The loadings of the final solution, which explained 43% of variance, are reported in Table 1 (Study 1). Markers with substantial primary loadings and no sizeable secondary loadings defined each facet. An exception is the facet responsibility for which some adjectives showed secondary loadings on impulse control. One of the items, 'rash' (sconsiderato), had a slightly larger loading on impulse control than on responsibility, but it was nonetheless selected for the responsibility IAT, for which the number of items would have been insufficient otherwise. Despite our best efforts, we were only able to identify 39 instead of 40 markers, the missing marker being an adjective for the positive pole of responsibility. To fill in the missing marker, we added on theoretical grounds 'dependable' (fidato), which was not present in the original list.

STUDY 2: DIFFERENTIAL ROLES OF CONSCIENTIOUSNESS FACETS

In this study, we built one IAT for each facet of conscientiousness using the stimuli from Study 1 and examined their convergent and discriminant validity (Campbell & Fiske, 1959). We investigated how facets of conscientiousness, assessed with both direct and indirect measures, related to different aspects of self-control and to working memory capacity.

Method

Participants

One hundred and fifty subjects participated in the study for course credit or monetary compensation. Two participants were excluded from all analyses because their pattern of responses (more than 30% errors in the IAT) indicated random responding. The final sample included 148 subjects (114 women, M age = 22.6 years, SD = 4.2), none of whom participated in Study 1. The data from five participants (one male and four female students) were discarded from the analyses involving the Automated Operation Span Task (A-OSPAN), because they committed too many errors in the mathematical task. Two female participants were discarded from the analyses involving the behavioural indicators and the peer-reports, because they did not return these questionnaires (Procedure section).

Measures

We assessed conscientiousness facets using four IATs, three self-report scales, one peer-report instrument and a questionnaire with behavioural indicators. We also measured working memory capacity and self-control.

Implicit Association Tests. Four IATs were administered; these assessed orderliness, impulse control, industriousness and responsibility. Participants were instructed to classify words in the categories that were presented in the upper part of the screen using two keys ('E' and 'I'). The target categories were *Me* versus *Others*, whereas the attribute categories in the four different IATs were *Controlled* versus *Impulsive*, *Ordered* versus *Disordered*, *Industrious* versus *Lazy* and *Reliable* versus *Unreliable*. The stimuli were presented individually and in a random order in the middle of the screen. The stimuli for the attribute categories were those identified in Study 1, while the stimuli for the target categories were *me* (me), *io* (I), *mio* (mine), *mia* (mine) and *miei* (mine) for category *Me* and *altri* (other), *altre* (other), *essi* (they), *esse* (they) and *loro* (them) for category *Others*. Table 2 reports the sequence of the blocks for the IAT orderliness; the remaining IATs had an analogous structure. A red X appeared in the middle of the screen for 200 milliseconds if the participant did not answer correctly (i.e. classified the stimulus in the wrong category), and there was no built-in penalty procedure (Greenwald, Nosek & Banaji, 2003). The order of the four IATs, as well as the order of the blocks, was counterbalanced across participants, with half of the participants having the compatible block (e.g. me–ordered) and the relative practice trials presented first, and the other half having the incompatible block (e.g. others–ordered) presented first. Four D scores (Greenwald et al., 2003) were computed from the combined categorization blocks (Blocks 3 and 5 in Table 2) of each IAT. Latencies below 300 milliseconds and above 3000 milliseconds were recoded to 300 and

Table 2. Sequence of the blocks in the Implicit Association Test (IAT) for the IAT orderliness

			Response key assignment	
Block	*N* of trials	Task	Left key ('E')	Right key ('I')
1	20	Target discrimination	Ordered	Disordered
2	20	Attribute discrimination	Me	Others
3	60 + 2	Initial combined task	Me, Ordered	Others, Disordered
4	20	Reversed target discrimination	Disordered	Ordered
5	60 + 2	Reversed combined task	Me, Disordered	Others, Ordered

Note: The attribute discrimination block was presented to each participant only in the first IAT, but not in the subsequent three IATs.

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3000 milliseconds, respectively; error latencies were recoded as the average correct latency in the block plus a 600-millisecond penalty. The D scores were computed by subtracting the average of the transformed latencies in the compatible blocks (i.e. conscientious–me) from the average of the transformed latencies in the incompatible block (i.e. conscientious–others), divided by the standard deviation of the correct latencies in both critical blocks. Additionally, two D scores for each IAT were also computed, one on the odd trials and one on the even trials, which served as indicators in confirmatory factor analysis (CFA). To minimize the use of response strategies, we used Back et al.'s (2009) strategy of including a break of 2 minutes between each pair of IATs. During the break, participants were presented with Rorschach pictures and were asked to write down their ideas concerning the inkblot.

Adjective Checklist of Conscientiousness. Participants indicated how each of the 40 adjectives used as stimuli in the IAT described them, on a scale from 1 (*it does not describe me at all*) to 5 (*it describes me completely*). Four facets were assessed: orderliness, industriousness, impulse control and responsibility. Two parcel scores including five items for each facet were also computed to serve as indicators in CFA.

Chernyshencko Conscientiousness Scale. The 60-item Chernyshencko Conscientiousness Scale (CCS; Green, O'Connor, Gartland & Roberts, 2015; Hill & Roberts, 2011) assesses six conscientiousness facets with 10 items each: order (e.g. 'I become annoyed when things around me are disorganized'), self-control ('I do not take unnecessary risks'), industriousness ('I have high standards and work towards them'), responsibility ('If I am running late, I try to call ahead to notify those who are waiting for me'), virtue ('If a cashier forgot to charge me for an item I would tell him/her') and traditionalism ('I support long-established rules and traditions'). Participants indicated their agreement with each statement on a scale from 1 (*agree strongly*) to 5 (*disagree strongly*). Note that this questionnaire includes two additional facets, virtue and traditionalism, that have been argued to be lower-level aspects of conscientiousness, although they tend to be recovered less often than the main four facets.

HEXACO Personality Inventory. We also administered the 32-item conscientiousness scale of the HEXACO-PI (Lee & Ashton, 2004). Participants indicated their agreement with each statement, on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Furthermore, a close friend rated the participant using the peer-report form of the same questionnaire. The scale assessed the four facets: prudence, diligence, organization and perfectionism. A sample item is 'I plan ahead and organize things, to avoid scrambling at the last minute'.

Behavioural indicators. This scale was adapted from Jackson et al. (2010). Using a scale from 1 (*never*) to 5 (*always*), participants indicated the frequency with which they performed each of 50 behaviours (25 reversed), 10 for each of five facets: orderliness (e.g. 'Used a planner to schedule the day's events'), impulse control (e.g. 'Buy something on a whim'), responsibility ('Play sick to avoid doing something', reverse scored), industriousness (e.g. 'Put off work until the last minute') and traditionalism (e.g. 'Gave up my bus seat to an elderly person').

Start and stop control scales (De Boer et al., 2011). Participants indicated the extent to which each of 18 statements described them on a scale from 1 (*it does not describe me at all*) to 5 (*it describes me completely*). Each aspect of self-control was assessed with nine items: start control (e.g. 'When there is much distraction, I am able to focus on one thing in order to get it done') and stop control (e.g. 'I can easily stop doing something fun that I know to be bad for me').

Automated Operation Span Task (Unsworth, Heitz, Engle & Schrock, 2005). Working memory capacity was assessed with an Automatic Operation Span Task (Conway et al., 2005; Turner & Engle, 1989; Unsworth et al., 2005). In each trial, participants needed to recall a series of three to seven letters in the correct presentation order. Before each letter, a simple math operation [e.g. $(1 \times 2) + 1 = ?$] was presented, followed by a possible solution to which participants had to indicate whether it was correct. As recommended by Unsworth and colleagues, participants were explicitly requested to be very accurate in the mathematical operations. Their data were discarded if their accuracy was below 85%. Participants completed three practice blocks followed by 75 test trials. Trials were presented in random order. The A-OSPAN score corresponded to the number of the correctly recalled letters across test trials (Conway et al., 2005).

Procedure

Participants were recruited for a 'personality study'. Upon arrival, they took part in a series of computerized tasks in a fixed sequence: IATs, CCS, HEXACO-PI, Adjective Checklist of Conscientiousness (ADJ) and start and stop control scales.[5] After completing the session, each participant was given one envelope that included the behavioural indicators questionnaire for the participant to complete and a second envelope that contained the HEXACO-PI peer-report questionnaire. Instructions asked the participants to give the second envelope 'to a well acquainted person, for instance to a close friend'. The participants returned the envelopes the subsequent week to the experimenter who thanked them, debriefed them and compensated them.

Analytic method

We used PCA for inspecting the structure of the ADJ scale and on the self-report scales (CCS, HEXACO-PI and ADJ) for computing component scores used in further analyses. We then inspected the multitrait–multimethod (MTMM; Campbell & Fiske, 1959) correlation matrix to assess convergent and discriminant validity of the IATs with respect to both the ADJ and the component scores. The ADJ included the same items as the IATs, allowing a more precise control

[5]For exploratory purposes, an additional five-item short scale of perfectionism that we assembled was administered. The psychometric properties of this scale however were not satisfactory, and therefore, results involving this scale are not considered.

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Table 3. Correlation matrix

	IAT				ADJ				CCS	
	1	2	3	4	5	6	7	8	9	10
IAT										
1. Orderliness	*.73*									
2. Impulse control	*.35****	*.64*								
3. Industriousness	*.41****	*.14*	*.60*							
4. Responsibility	*.32****	*.38****	*.35****	*.79*						
ADJ										
5. Orderliness	***.20****	*.15*	*.06*	*.02*	*.89*					
6. Impulse control	*.09*	***.26*****	*−.02*	*.13*	*.42****	*.90*				
7. Industriousness	*.18**	*.04*	***.21****	*.12*	*.46****	*.24***	*.82*			
8. Responsibility	*.12*	*.20**	*.17**	***.21*****	*.35****	*.52****	*.56****	*.80*		
CCS										
9. Order	**.19***	.13	−.02	.01	**.82*****	.37***	.28***	.33***	.89	
10. Self-control	.22**	**.29*****	.13	.20*	.48***	**.80*****	.23**	.48***	.44***	.84
11. Industriousness	.13	−.06	**.16**	−.03	.33***	.13	**.71*****	.37***	.13	.16
12. Responsibility	.15	.05	.26**	**.08**	.46***	.38***	.47***	**.47*****	.33***	.44***
13. Traditionalism	.10	.07	−.04	−.01	.40***	.44***	.30***	.36***	.31***	.40***
14. Virtue	.03	.05	.02	−.03	.14	.28***	.38***	.38***	.13	.23**
HEXACO-PI self-report										
15. Organization	**.22****	.09	.02	.01	**.84*****	.32***	.32***	.30***	**.89*****	.42***
16. Prudence	.23**	**.31*****	.17*	.14	.40***	**.76*****	.24**	.40***	.35***	**.79*****
17. Diligence	.17*	.04	**.22****	.09	.38***	.07	**.80*****	.39***	.18*	.13
18. Perfectionism	.14	.15	−.05	.04	.65***	.32***	.46***	**.32*****	.48***	.36***
PCA scores										
19. Orderliness	**.21***	.13	.01	.02	.92***	.38***	.36***	.34***	.96***	.46***
20. Impulse control	.19*	**.31*****	.10	.17*	.47***	.93***	.26**	.51***	.41***	.93***
21. Industriousness	.17*	.01	**.22****	.06	.42***	.15	.90***	.47***	.20*	.19*
HEXACO-PI peer-report										
22. Organization	**.08**	.02	−.01	−.01	**.52*****	.22**	.17*	.16	**.58*****	.25**
23. Prudence	.11	**.10**	.01	.05	.35***	**.54*****	.20*	.23**	.25**	**.39*****
24. Diligence	−.03	−.10	**.07**	−.07	.17*	.08	**.39*****	.20*	.06	.06
25. Perfectionism	.08	.01	.00	−.03	.42***	.29***	.34***	.19*	.32***	.27**
Self-reported behaviours										
26. Orderliness	**.18***	−.01	.09	.08	**.59*****	.18*	.35***	.25**	**.58*****	.23**
27. Impulse control	.16*	**.14**	.13	.13	.22**	**.51*****	.23**	.26**	.17*	**.53*****
28. Industriousness	.03	−.03	**.08**	.10	.36***	.16*	**.60*****	.29***	.17*	.19*
29. Responsibility	.05	−.07	.20*	**.07**	.32***	.26**	.17*	.16	.27**	.22**
30. Traditionalism	.08	.11	−.08	.11	.19*	.41***	.32***	.34***	.15	.32***
Other measures										
31. Start control	.10	−.03	.14	.06	.14	−.04	.47***	.08	−.03	−.03
32. Stop control	.18*	.25**	.11	.16	.39***	.69***	.27***	.39***	.33***	.72***
33. A-OSPAN	−.25**	−.16	−.12	−.08	−.22**	−.10	−.16	−.20*	−.25**	−.14

Note: Sample size $N = 148$, except for correlations involving HEXACO-PI peer-report and self-reported behaviours ($N = 146$), for correlations involving A-OSPAN ($N = 143$) and for correlations involving both A-OSPAN and HEXACO-PI peer-report or both A-OSPAN and self-reported behaviours ($N = 141$). Reliabilities are reported on the main diagonal. Monotrait–heteromethod correlations for the conscientiousness measures are reported in bold. The multitrait–multimethod matrix between the IATs and the ADJ is shown in italics. IAT, Implicit Association Test; PCA scores, component scores from principal component analysis, ADJ, Adjective Checklist, CCS, Chernyshenko Conscientiousness Scale; A-OSPAN, Automated Operation Span Task; HEXACO-PI, HEXACO Personality Inventory. *$p < .05$; **$p < .01$; ***$p < .001$.

of differences in item content between direct and indirect measures, while the component scores allowed a more heterogenous assessment of conscientiousness facets, as they combined information provided by several measures.These MTMM matrices were also analysed at the level of latent variables using CFA (e.g. Brown, 2015), as implemented in the R package *lavaan* (Rosseel, 2012). Convergent validity was established by inspecting whether the monotrait–heteromethod correlations (i.e. the correlations lying on the validity diagonal) were significantly different from zero. Discriminant validity was established by inspecting whether the correlations on the validity diagonal were larger than the correlations lying on the same row and column of the corresponding heterotrait–heteromethod triangles. Heterotrait–monomethod correlations larger than the monotrait–heteromethod ones were not interpreted as a lack of discriminant validity, because high heterotrait correlations are expected from measures that tap into the same personality factor while correlations in the .20–.30 range are common between indirect and direct measures of the same construct (Greenwald et al., 2009; Hofmann et al., 2005). For the same reason, our data did not allow a direct computation of latent method factors in CFA: Method factors would have been confounded with implicit and

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Table 3. (Continued)

	CCS				HEXACO-PI self-report				PCA scores		
	11	12	13	14	15	16	17	18	19	20	21
IAT											
1. Orderliness											
2. Impulse control											
3. Industriousness											
4. Responsibility											
ADJ											
5. Orderliness											
6. Impulse control											
7. Industriousness											
8. Responsibility											
CCS											
9. Order											
10. Self-control											
11. Industriousness	.82										
12. Responsibility	.40***	.61									
13. Traditionalism	.31***	.36***	.82								
14. Virtue	.39***	.35***	.52***	.81							
HEXACO-PI self-report											
15. Organization	.17*	.42***	.31***	.07	.87						
16. Prudence	.14	.37***	.30***	.14	.31***	.85					
17. Diligence	**.79****	.41***	.22**	.31***	.18*	.17*	.73				
18. Perfectionism	.49***	.36***	.33***	.23**	.42***	.32***	.45***	.78			
PCA scores											
19. Orderliness	.19*	.42***	.35***	.11	.96***	.36***	.24**	.52***	.94		
20. Impulse control	.15	.43***	.41***	.23**	.37***	.92***	.13	.37***	.43***	.91	
21. Industriousness	.91***	.46***	.30***	.38***	.23**	.20*	.94***	.51***	.28***	.19*	.91
HEXACO-PI peer-report											
22. Organization	.05	.31***	.07	−.01	**.62****	.15	.10	.22**	.61***	.22**	.11
23. Prudence	.20*	.27**	.31***	.14	.22**	**.45****	.16*	.32***	.27***	.50***	.20*
24. Diligence	**.43****	.38***	.23**	.19*	.04	.07	**.49****	.18*	.08	.08	.48***
25. Perfectionism	.44***	.43***	.32***	.21**	.29***	.26**	.39***	**.42****	.35***	.29***	.43***
Self-reported behaviours											
26. Orderliness	.25**	.42***	.28***	.04	**.59****	.23**	.30***	.40***	.62***	.23**	.32***
27. Impulse control	.23**	.37***	.20*	.21*	.17*	**.57****	.20*	.20*	.18*	.58***	.24**
28. Industriousness	**.56****	.40***	.23**	.17*	.22**	.14	**.53****	.40***	.25**	.18*	.61***
29. Responsibility	.10	**.52****	.18*	.05	.37***	.22**	.11	.06	.33***	.25**	.13
30. Traditionalism	.23**	.27***	**.46****	.44***	.12	.30***	.21*	.20*	.15	.38***	.27***
Other measures											
31. Start control	.47***	.24**	.02	.13	.06	.05	.48***	.18*	.05	.00	.52***
32. Stop control	.20*	.44***	.32***	.25**	.29***	.73***	.19*	.33***	.34***	.77***	.23**
33. A-OSPAN	−.01	−.14	−.05	.02	−.26**	−.16	−.12	−.10	−.26**	−.14	−.10

explicit conscientiousness factors. Convergent and discriminant validity was also examined with respect to the peer-reports and to the self-report behavioural indicators.

We used a network approach for examining the relations between conscientiousness facets and other variables considered in the study. The networks were computed with the R package *parcor* (Krämer et al., 2009), and they were drawn using package *qgraph* (Epskamp et al., 2015; Epskamp, Cramer, Waldorp, Schmittmann & Borsboom, 2012).

Results

Table 3 reports the correlations among all the measures administered and the reliabilities on the main diagonal. The reliabilities of the self-report scales were generally satisfactory, and the reliabilities of the IATs were acceptable, ranging between .60 and .79.

Preliminary analysis of self-report scales

Principal component analysis on adjective checklist items. We replicated the analysis performed in Study 1 on the items of the ADJ. Item 'fidato' (trustworthy), which had not been considered in Study 1, was also included. The results of this analysis are reported in Table 1 (Study 2). The structure of the ADJ was similar to that emerged in Study 1: The four factors replicated the impulse control, orderliness, industriousness and responsibility factors found in Study 1, with some of the responsibility items having cross-loadings with the factor impulse control. Item fidato (trustworthy), which had been added on theoretical grounds, loaded on responsibility as expected.

Principal component analysis on self-report scales of conscientiousness (Adjective Checklist of Conscientiousness, Chernyshencko Conscientiousness Scale and HEXACO Personality Inventory). Given the heterogeneity in the facets measured by the questionnaires, we did not have

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Table 3. (Continued)

	HEXACO-PI peer-report				Behavioural indicators					Other	
	22	23	24	25	26	27	28	29	30	31	32
IAT											
1. Orderliness											
2. Impulse control											
3. Industriousness											
4. Responsibility											
ADJ											
5. Orderliness											
6. Impulse control											
7. Industriousness											
8. Responsibility											
CCS											
9. Order											
10. Self-control											
11. Industriousness											
12. Responsibility											
13. Traditionalism											
14. Virtue											
HEXACO-PI self-report											
15. Organization											
16. Prudence											
17. Diligence											
18. Perfectionism											
PCA scores											
19. Orderliness											
20. Impulse control											
21. Industriousness											
HEXACO-PI peer-report											
22. Organization	.88										
23. Prudence	.29***	.82									
24. Diligence	.12	.27**	.76								
25. Perfectionism	.33***	.49***	.59***	.82							
Self-reported behaviours											
26. Orderliness	**.40*****	.17*	.14	.29***	.82						
27. Impulse control	.17*	**.27****	.09	.20*	.22**	.72					
28. Industriousness	.17*	.11	**.31*****	.28***	.59***	.33***	.77				
29. Responsibility	.30***	.17*	.10	.11	.53***	.30***	.39***	.82			
30. Traditionalism	.06	.20*	.21*	.23**	.40***	.37***	.46***	.38***	.68		
Other measures											
31. Start control	.10	.16	.32***	.23**	.09	.16	.35***	.12	.15	.73	
32. Stop control	.11	.39***	.13	.27***	.31***	.65***	.26**	.33***	.45***	.08	.73
33. A-OSPAN	−.12	.05	.01	−.01	−.05	−.05	−.04	−.04	−.05	−.14	−.15

strong *a priori* expectations on how many general facets could have emerged. We performed a PCA to inspect which self-report facets could be recovered, following a strict empirical criterion to decide how many to retain. While four eigenvalues were larger than one (the first five eigenvalues were 6.05, 2.17, 1.65, 1.00 and 0.70), the scree plot indicated a clear break after the third component, and results of a parallel analysis also clearly suggested to extract three components (the first four random eigenvalues were 1.56, 1.41, 1.30 and 1.23). The three components could be easily interpreted as impulse control, industriousness and orderliness (Table 4, Solution 1). Because some scales did not clearly load on a single component, we iteratively excluded them and repeated the analysis in order to describe the three facets with the simplest possible factor structure (Table 4, Solution 2). We computed the three component scores using the regression method and saved them for the subsequent analyses.

Aim 1: development of indirect measures of conscientiousness and test of convergent and discriminant validity

Implicit Association Tests and adjective checklist

The first rows and columns of Table 3 report the multitrait–multimethod matrix (Campbell & Fiske, 1959) of the four facets of conscientiousness assessed using both IAT and the ADJ. The monotrait–heteromethod correlations were all significantly different from zero, their magnitude being in line with the typical correlations between IATs and self-reports (Greenwald et al., 2009; Hofmann et al., 2005; Schmukle et al., 2008), and they were higher than the heterotrait–heteromethod correlations lying on the same rows and columns of the heterotrait–heteromethod block.

We fitted a CFA model (Figure 1A) in which the ADJ parcels and the IAT parcels were allowed to load on latent implicit and explicit facets of conscientiousness, respectively.

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Table 4. Principal component analysis of conscientiousness scales

	Component loadings							
	Solution 1				Solution 2			
	ORD	IMC	IND	u^2	ORD	IMC	IND	u^2
CCS								
Industriousness	.00	−.04	**.90**	.20	−.06	.00	**.93**	.17
Self-control	.18	**.87**	−.17	.18	.08	**.90**	−.01	.13
Orderliness	**.91**	.07	−.05	.13	**.97**	.01	−.07	.08
Responsibility	.18	**.37**	**.38**	.52	—	—	—	
Virtue	**−.24**	**.52**	**.35**	.55	—	—	—	
Traditionalism	.05	**.52**	**.21**	.59	—	—	—	
HEXACO-PI (self-report)								
Diligence	.07	−.11	**.92**	.18	−.01	−.05	**.95**	.11
Prudence	.11	**.83**	−.16	.30	−.05	**.94**	.03	.15
Organization	**.94**	.01	−.01	.12	**.99**	−.05	−.03	.07
Perfectionism	**.48**	.07	**.41**	.46	—	—	—	
ADJ								
Industriousness	.13	.04	**.84**	.20	.10	.05	**.87**	.17
Impulse control	.06	**.93**	−.18	.16	−.02	**.94**	−.03	.14
Orderliness	**.86**	.08	.18	.09	**.84**	.08	.18	.11
Responsibility	−.01	**.55**	**.36**	.44	—	—	—	
	Correlations among components							
ORD	1				1			
IMC	.37	1			.43	1		
IND	.22	.32	1		.28	.19	1	

Note: Loadings larger than .20 are represented in bold. u^2, uniqueness; IND, industriousness; ORD, orderliness; IMC, impulse control; CCS, Chernyshenko Conscientiousness Scale; ADJ, Adjective Checklist.

The identification of the model was ensured by fixing the latent variances to 1, and the correlations among the latent variables were estimated. The model fitted the data well [$\chi^2(76) = 92.22$, $p = .099$, comparative fit index = 0.985, root mean square of approximation = 0.038, standardized root mean square residual = 0.045]. Table 5 reports the correlations among the latent facets, which indicated clear convergent and discriminant validity for all facets with the partial exception of responsibility, as the correlation between explicit and implicit responsibility was significant but slightly lower than the correlation between explicit responsibility and implicit impulse control. The heterotrait–monomethod correlations were generally high for both the implicit and explicit facets, with the correlations between industriousness and impulse control being consistently lowest in all the heterotrait–monomethod and heterotrait–heteromethod blocks.

To inspect whether the implicit and explicit conscientiousness facets loaded on a general conscientiousness factor, we fitted an additional CFA model (Figure 1B), in which the facets were allowed to load on superordinate implicit and explicit conscientiousness factors. The model fit was reasonable [$\chi^2(95) = 158.38$, $p < .001$, comparative fit index = 0.943, root mean square of approximation = 0.067, standardized root mean square residual = 0.073], and the second-order factor loadings were consistently large on both implicit and explicit conscientiousness factors. Crucially, the implicit and explicit conscientiousness factors correlated significantly ($r = .34$, $p < .001$), ruling out the possibility that the loadings on the implicit conscientiousness factor could simply reflect IAT's method variance.

Implicit Association Tests and all self-reports of conscientiousness

The orderliness, impulse control and industriousness IATs showed clear convergent and discriminant validity also when compared with the three component scores of the self-report facets (Table 3). A CFA of convergent and discriminant validity considering all of the self-report scales of orderliness, impulse control and industriousness from the CCS, ADJ and HEXACO-PI is reported in the Supporting Information S2 and further confirmed the convergent and discriminant validity of the IATs.

Peer-reports and self-report behaviours

Although self-reports and peer-reports showed satisfactory convergent and discriminant validity, the IATs did not converge with the peer-report scales (all p-values > .25, see Table 3 for more details). Additionally, while self-reports of conscientiousness correlated with the self-reported behaviours, the pattern of correlations with the IATs was less clear. The orderliness IAT correlated weakly but significantly with the behavioural scores of orderliness ($r = .18$, $p = .026$) and impulse control ($r = .16$, $p = .047$), while the correlation between the impulse control IAT and the corresponding behavioural scale was not significant ($r = .14$, $p = .086$). Additionally, the industriousness IAT correlated with the behavioural scale for responsibility ($r = .20$, $p = .013$). No other significant correlation emerged between the IATs and the behavioural scores (p-values > .10, see Table 3 for details).

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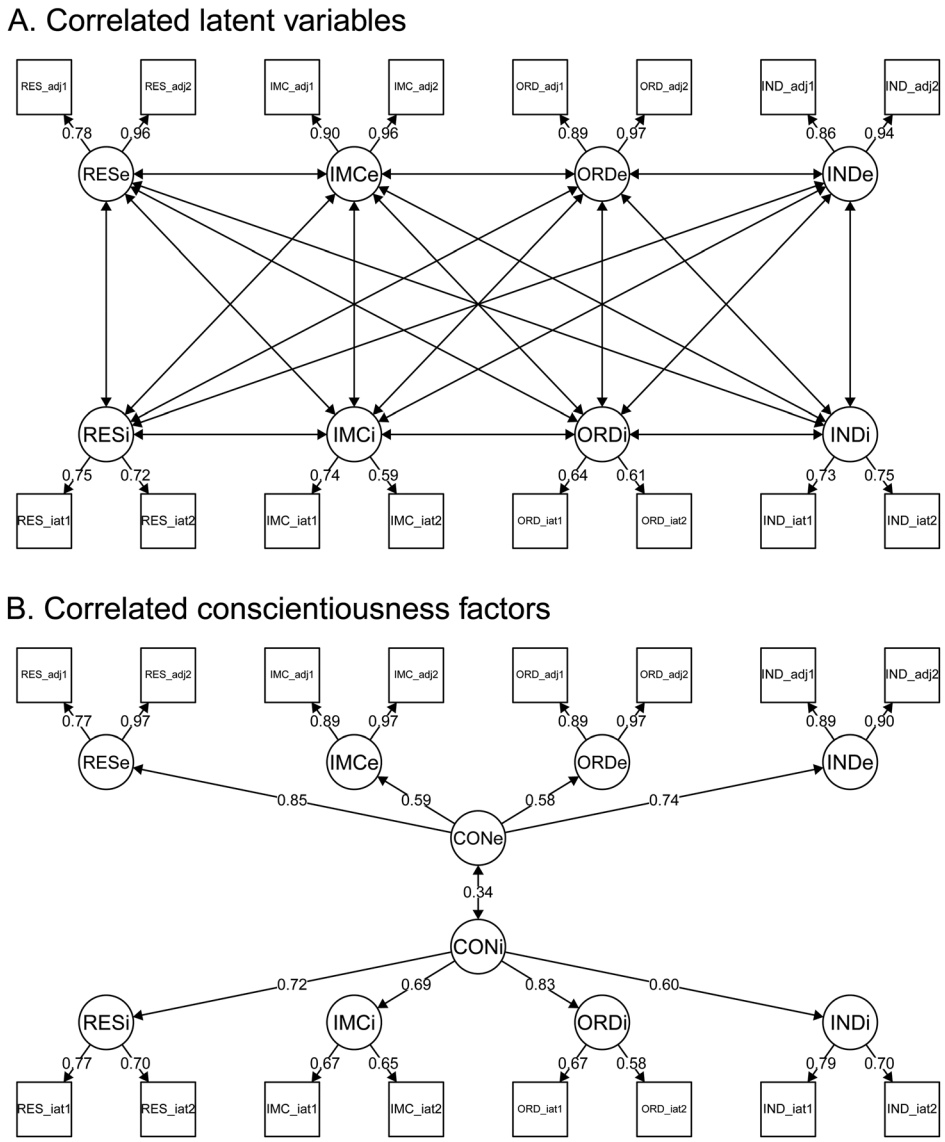

Figure 1. Confirmatory factor analysis models of implicit and explicit conscientiousness facets. Circles indicate latent variables, and squares indicate observed variables. CONe and CONi indicate the explicit and implicit conscientiousness factors, respectively. RESe, IMCe, ORDe and INDe indicate the explicit responsibility, impulse control, orderliness and industriousness facets, while RESi, IMCi, ORDi and INDi indicate the corresponding implicit facets. For the observed variables, the prefixes indicate the facets, while the suffixes '_iat1' or '_iat2' indicate that the score has been computed on an Implicit Association Test, and the suffixes '_adj1' and '_adj2' indicate that the score has been computed on the items of the adjective checklist. The correlations among latent variables in Figure 1A are reported in Table 5. The figures were obtained with the R package semPlot (Epskamp, 2014, 2015).

Table 5. Correlations among implicit and explicit latent conscientiousness facets

	RESi	IMCi	ORDi	INDi	RESe	IMCe	ORDe	INDe
RESi	1							
IMCi	.58***	1						
ORDi	.52***	.58***	1					
INDi	.49***	.18	.62***	1				
RESe	**.22***	.25*	.12	.19*	1			
IMCe	.16	**.37*****	.15	−.03	.57***	1		
ORDe	.06	.20*	**.27***	.11	.40***	.44***	1	
INDe	.14	.04	.24*	**.26*****	.64***	.25**	.53***	1

Note: sample size $N = 148$. Monotrait–heteromethod correlations are reported in bold. RESi, implicit responsibility; IMCi, implicit impulse control; ORDi, implicit orderliness; INDi, implicit industriousness; RESe, explicit responsibility; IMCe, explicit impulse control; ORDe, explicit orderliness; INDe, explicit industriousness. *$p < .05$; **$p < .01$; ***$p < .001$.

Aim 2: conscientiousness and self-control

Consistent with our predictions, the start and stop control scales showed a differential pattern of correlations with the facets of conscientiousness, both assessed with direct and indirect measures (Table 6). Across measures, the strongest correlations were between stop control and impulse control on the one hand and between start control and industriousness on the other hand, although the correlation between start control and the industriousness IAT was not significant ($r = .14$, $p = .086$). The same patterns were also observed when the individual self-report measures were considered, both between start control and industriousness scales (correlations ranging between .47 and .48, all p-values $< .001$) and between stop control and impulse control scales (correlations ranging between .69 and .73, all p-values $< .001$, see Table 3 for details).

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Table 6. Correlations between self-control and conscientiousness facets

	IAT				PCA scores		
	Orderliness	Impulse control	Industriousness	Responsibility	Orderliness	Impulse control	Industriousness
Start control	.10	−.03	.14	.06	.05	.00	.52***
Stop control	.18*	.25**	.11	.16	.34***	.77***	.23**

Note: Sample size $N = 148$. IAT, Implicit Association Test; PCA scores, component scores from principal component analysis. *$p < .05$; **$p < .01$; ***$p < .001$.

Aim 3: conscientiousness and working memory

Working memory capacity was negatively correlated with the orderliness IAT ($r = -.25$, $p = .003$), the self-report component score of orderliness ($r = -.26$, $p = .002$) and all individual self-report orderliness facets (all p-values $< .01$, see Table 3 for details), but it was not significantly associated with any other conscientiousness domains, with the exception of responsibility from the ADJ ($r = -.20$, $p = .017$).

Aim 4: network analysis

We used network analysis for investigating the differential relationships among conscientiousness facets, self-control and working memory. Figure 2 shows the adaptive lasso network computed on the IATs, the component scores of the self-report questionnaires, the peer-report scales of the HEXACO-PI, the self-report behaviours, the start and stop control scales and the A-OSPAN score. The network was computed on the 141 participants who completed all of the measures. The values of the partial correlation corresponding to each edge are reported in the Supporting Information S3.

The self-reports, self-reported behaviours and peer-reports generally clustered within each conscientiousness facet. Exceptions were traditionalism and responsibility behaviours and the peer-reported perfectionism that were positioned interstitially between different clusters. The IATs formed a cluster (on the right part of the plot), and the impulse control and the industriousness IATs were connected with the corresponding self-report facets. The three self-report conscientiousness facets were also connected with each other and so were the IATs, with the noticeable exception of a missing connection between industriousness and impulse control both for the IATs and for the self-reports. This pattern confirms the weak heterotrait–monomethod correlations between industriousness and impulse control (Table 5).

The IATs were not connected to any of the self-report behavioural scores. This indicates that, once the other relevant variables in the network were partialled out, the correlations between the IATs and the self-report behaviours ceased to be significant. We further inspected whether the IATs shared unique variance with self-report behaviours after partialling out the three component scores of conscientiousness facets. Only the partial correlation between the industriousness IAT and the responsibility behavioural scale remained significant (partial $r = .19$, $p = .020$), while the correlations between the orderliness IAT and the orderliness behaviour (partial $r = .06$, $p = .487$) and that between the orderliness IAT impulse control behaviour (partial $r = .06$, $p = .468$) waned after controlling for direct measures of conscientiousness facets.[6] The fact that a link between the industriousness IAT and the responsibility behavioural scale was missing in the network depends on the stricter control imposed by network analysis, in which variables other than the self-report conscientiousness facets are controlled for.

The start and stop control scales clearly belonged to the industriousness and impulse control clusters, respectively. Although the impulse control IAT correlated significantly with stop control (Table 3), the corresponding connection was missing in the network. We further inspected the relationship between the IATs and self-control by performing a multiple regression in the prediction of stop control: After including the three component scores of conscientiousness, the impulse control IAT ceased to be a significant predictor of stop control ($\beta_{IAT} = .03$, $p = .780$), the only significant predictor being the impulse control component score ($\beta_{IMC} = .46$, $p < .001$).[7]

The IATs and self-report of orderliness were not connected directly, but they had only one common neighbour, namely working memory (node A-OSPAN), to which they were both connected by a negative edge. Importantly, the A-OSPAN was not connected to any other facet in the network, suggesting that this relationship was specific to orderliness. We explored further this result by performing a multiple regression on the working memory capacity score. We entered the component scores of the self-report facets of conscientiousness in the first step and the orderliness IAT in the second (Table 7, Analysis 1). The orderliness IAT showed incremental validity over and above the self-reports ($\Delta R^2 = .04$, $p = .017$). A similar result was obtained when the ADJ scales were considered instead of the component scores (Table 7, Analysis 2). The fact that the self-report and the indirect scores of orderliness were uniquely connected to A-OSPAN suggests that the variance shared between orderliness and working memory capacity cannot be fully understood by considering only self-report measures of orderliness.

[6]The pattern of results was substantially similar if the four ADJ scales were partialled out, with the partial correlations being .20 ($p = .014$) between the industriousness IAT and the responsibility behaviour, .08 ($p = .335$) between the orderliness IAT and the orderliness behaviour and .13 ($p = .119$) between the orderliness and the impulse control behaviour.

[7]The pattern of results was the same if the four ADJ scales were controlled for, $\beta_{IAT} = .13$ ($p = .225$), $\beta_{IMC} = .54$ ($p < .001$).

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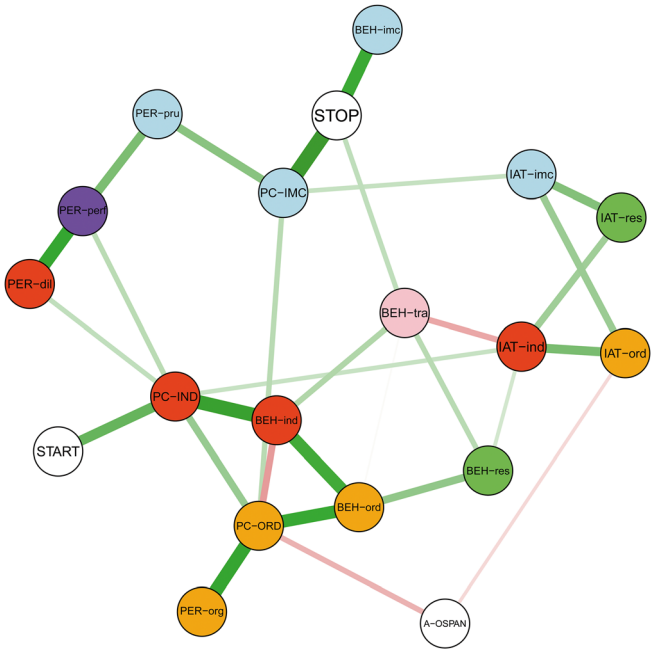

Figure 2. Network of conscientiousness. The network includes the four Implicit Association Tests (IATs), IAT-ord = orderliness, IAT-imc = impulse control, IAT-ind = industriousness and IAT-res = responsibility; the component scores of self-report questionnaires, PC-ORD = orderliness, PC-IMC = impulse control and PC-IND = industriousness; the self-reported behaviours, BEH-ord = orderliness, BEH-imc = impulse control, BEH-ind = industriousness, BEH-res = responsibility and BEH-tra = traditionalism; the peer-reports of the HEXACO-PI scales, PER-org = organization, PER-dili = diligence, PER-pru = prudence and PER-perf = perfectionism; the start and stop control scales (START and STOP); and the A-OSPAN. Nodes are coloured according to facets of conscientiousness: orange = orderliness, blue = impulse control, red = industriousness, green = responsibility, purple = perfectionism and pink = traditionalism.

Table 7. Hierarchical multiple regression analyses predicting A-OSPAN

Predictor	R^2	β
	Analysis 1	
Step 1	.07 (p = .018)	
PC-ORD		−.24 (p = .011)
PC-IMC		−.04 (p = .656)
PC-IND		−.02 (p = .791)
Step 2	R^2 = .11 (p = 003), ΔR^2 = .04 (p = .017)	
PC-ORD		−.21 (p = .021)
PC-IMC		−.02 (p = .834)
PC-IND		.00 (p = .993)
IAT-ORD		−.20 (p = .017)
	Analysis 2	
Step 1	.07 (p = .042)	
ADJ-ORD		−.19 (p = .052)
ADJ-IMC		.07 (p = .510)
ADJ-IND		.01 (p = .949)
ADJ-RES		−.17 (p = .138)
Step 2	R^2 = .11 (p = 007), ΔR^2 = .04 (p = .014)	
ADJ-ORD		−.16 (p = .095)
ADJ-IMC		.06 (p = .524)
ADJ-IND		.03 (p = .800)
ADJ-RES		−.17 (p = .140)
IAT-ORD		−.21 (p = .014)

Note: Sample size N = 143. PC-ORD, PC-IMC and PC-IND indicate component scores for orderliness, impulse control and industriousness, respectively; ADJ-ORD, ADJ-IMC, ADJ-IND and ADJ-RES indicate the orderliness, impulse control, industriousness and responsibility scales of the adjective checklist. IAT-ORD, orderliness IAT.

DISCUSSION

The main aim of our work was developing four IATs for assessing conscientiousness facets and testing their convergent and discriminant validity. Additionally, we aimed at exploring the connections between conscientiousness and self-control and between conscientiousness and working memory, and we showed how network analysis can be used for analysing complex patterns of relationships in personality research. In the following sections, we discuss how our studies fulfilled each aim and suggest how future research on these topics could further expand our results.

Aim 1: development of an indirect assessment of conscientiousness and test of convergent and discriminant validity

The IATs developed here showed convergent and discriminant validity with self-report measures at the facet level. This finding contradicts prior work documenting a lack of convergent and discriminant validity among direct and indirect measures of conscientiousness, when the construct was measured as an entire domain. Our research thus points to the possibility that indirect measures of conscientiousness can systematically converge with self-report measures *if* the facet level is taken into consideration *and* the stimuli are carefully selected. This result may also reflect the fact that the associations between the self and the traits (Back et al., 2009) are, in some cases, more clearly established at the level of specific facets than for the general domain.

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Note that the level of precision achieved in this investigation was possible only by using a strategy to identify the best markers of conscientiousness based on the psycholexical methodology used in Study 1. A partial exception to this pattern of results is the responsibility facet. In Study 1, it did not emerge as clearly as the other three factors, and in Study 2, it could not be recovered as a facet when performing a PCA of all self-reports of conscientiousness and showed less clear discriminant validity. Previous studies showed that responsibility shares a portion of variance also with agreeableness (e.g. Roberts et al., 2004, 2005). One of the possible limitations of this study was not having included indirect and direct measures of agreeableness, which could instead be used in future studies aimed at clarifying the validity of indirect measures of responsibility.

While peer-report questionnaires correlated with the corresponding self-report facets, they did not converge with the IATs. This could reflect the fact that the manifestations of explicit conscientiousness may be more easily observable to others than the manifestations of corresponding implicit facets (e.g. Vazire, 2010). However, the lack of convergence between IATs and peer-reports may also stem from the fact that in our study only one peer rated each participant on a single measure, namely the HEXACO-PI. Future studies could overcome such limitation and improve the reliability of peer-report indicators by combining assessments by several raters on multiple scales.

The pattern of convergence between the IATs and self-report behaviours was mixed, with only some facets correlating with some of the behavioural scales, while self-reports of conscientiousness correlated with self-reported behaviours. Previous research has shown that the IAT is often a better predictor of spontaneous behaviours than of self-report behaviours (e.g. Back et al., 2009; Perugini & Leone, 2009). Our studies have established convergent and discriminant validity with self-reports of conscientiousness for at least three IATs. Future research can build upon our work by identifying nonverbal behavioural indicators specific for each of these facets and by performing a thorough investigation of the predictive validity of the IATs that we have developed.

Aim 2: conscientiousness and self-control

We explored the relationships between conscientiousness facets and different aspects of self-control (De Boer et al., 2011). Start control, the proactive component of self-control, characterized more clearly the industriousness facet of conscientiousness, while stop control, the inhibitive component of self-control, essentially coincided with impulse control. Stop control and impulse control should not be considered as separate constructs, considering for instance that the disattenuated correlation between the component score of impulse control and the stop control scale was almost perfect ($r = .95$, $p < .001$). Industriousness and impulse control were not directly connected in the networks (Figure 2) and showed generally lower correlations with each other than with other facets (Tables 3 and 5). This suggests that these two facets may reflect distinguishable mechanisms, but also common mechanisms responsible for their coalescence into the same superordinate personality dimension. Future research aimed at a precise identification of such mechanisms may build upon our results, which suggest that these facets both share self-control as a common core, but they also seem to rely on different types of self-control (De Boer et al., 2011).

The relationships with self-control were stronger for self-reports than for the IATs, which did not explain additional variance in self-control after controlling for self-report measures of conscientiousness. It is important to notice that in our study self-control was only assessed with self-reports, which tend to have low correlations with nonverbal assessments of self-control (Sharma et al., 2014). An important question for future research is whether a relationship between implicit conscientiousness facets and different aspects of self-control would emerge more clearly if nonverbal assessments of self-control were considered (e.g. Duckworth & Kern, 2011).

Aim 3: conscientiousness and working memory capacity

Results concerning working memory support the hypothesis that facets of conscientiousness have distinct relations with external variables. The A-OSPAN working memory score showed a negative correlation with both indirect and direct measures of orderliness. This relationship may reflect a mechanism that underlies individual differences in orderliness. Organizing one's belongings and tasks might reduce the complexity of the environment and schedule, ultimately decreasing working memory load. Orderliness can be sometimes just a way of storing some pieces of information in the environment (e.g. in agendas and drawers) instead of in memory. If this is the case, orderliness might be especially useful for individuals with low working memory capacity, as an alternative strategy to fulfil their everyday tasks; on the other hand, individuals with a high working memory capacity might be less compelled to be orderly.

Although a positive relationship between conscientiousness and working memory or executive functions has often been hypothesized (Fleming et al., 2015; Murdock et al., 2013; Williams et al., 2010), the presence of compensatory mechanisms could explain why such positive relationships are so rarely observed empirically. The negative relationship between orderliness and working memory could also be one of the determinants of a more general compensatory mechanism that has been described between conscientiousness and intelligence. According to this view, less intelligent individuals may become more conscientious to cope with their disadvantage (Chamorro-Premuzic & Furnham, 2004; Moutafi, Furnham & Crump, 2006; Moutafi, Furnham & Paltiel, 2004; but see Murray, Johnson, McGue & Iacono, 2014). One of the limitations of this study was that participants were mostly students, therefore individuals likely to be preselected for both conscientiousness and working memory. Future research should investigate the relationship between conscientiousness and working memory also in samples representative of the general population, to investigate this relationship when full variability is allowed both for conscientiousness and for working memory.

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We used a performance-based measure of working memory capacity. Unlike self-reports, such measures are largely unaffected by response tendencies (e.g. Paulhus, Lysy & Yik, 1998) and do not require introspection (Nisbett & Wilson, 1977). Despite these qualities, this performance-based measure does not allow assessing specific features of executive functions. We suggest that future studies should aim at elucidating connections between facets of conscientiousness, assessed with both direct and indirect measures, and facets of the executive functions (e.g. Miyake et al., 2000)—potential compensatory relationships among facets of conscientiousness and facets of executive functioning seem particularly interesting.

Aim 4: network analysis

We used a network approach, which allowed us to simultaneously estimate the organization among different measures of conscientiousness facets (indirect measures, self-reports and peer-reports) while investigating the interactions of such facets with external constructs. In this research scenario, networks provide the following: (1) a formal way of quantifying the net pairwise relationships among several variables (Krämer et al., 2009); (2) a graphical summary of these relationships (Epskamp et al., 2012), which can be more easily understood even when the pattern of relationships is not a simple one; and (3) a representation that helps the researcher to focus on the differential relationships among variables (e.g. Costantini et al., 2015; Cramer et al., 2012). This is particularly important when one's interest is especially directed towards uncovering personality mechanisms (e.g. Perugini, Costantini, Hughes & De Houwer, 2015). Crucially, network analysis can be used in exploratory settings, that is, without requiring researchers to put *a priori* constraints defining which relationships are allowed to vary and which are fixed (Costantini et al., 2015; Krämer et al., 2009). This is the case of some of our results: We could not have anticipated that a connection with working memory capacity would have been specific for facet orderliness or that a connection would be missing between industriousness and impulse control. Such results may have eluded us without network analysis. Nonetheless, the resulting representation is parsimonious, with only a small subset of the possible relationships among the variables being expressed. In the network in Figure 2 for instance, only 30 out of 171 possible edges are present.

Structural equation models (SEM), which have a much longer tradition in personality research, share some of the advantages of network analysis: They allow quantifying the relationships among several variables, and they can be represented in a graphically intuitive fashion. Furthermore, they allow controlling for measurement error, while network analysis does not include this possibility yet. Although SEM have been adapted to incorporate exploratory measurement models (Asparouhov & Muthén, 2009; Marsh, Morin, Parker & Kaur, 2014), such techniques are generally more appropriate for confirmatory research (i.e. with preregistered hypotheses), while in exploratory settings, they often allow for too many degrees of freedom on the side of the researcher (Wagenmakers et al., 2012). In network analysis performed with the adaptive lasso method, the presence or absence of a relationship is established in a data-dependent manner; therefore, this method does not include the same degrees of freedom while still providing a parsimonious account of the relationships among the variables of interest and preventing overfitting (McNeish, 2015). In conclusion, we believe that the network approach may prove a novel and helpful tool to the personality researcher in several situations, especially in a situation when there is interest in the following: (i) potential differential relationships (ii) without specific directional hypotheses that could be tested using confirmatory methods such as SEM. Nonetheless, network analysis and SEM should not be understood as opposed statistical approaches: Some of the most promising developments in both SEM and network analysis are likely to come from the union of these methods (Epskamp, Maris, Waldorp & Borsboom, in press).

CONCLUSIONS

Taken together, all the results support differential relationships of conscientiousness facets with other personality aspects or executive functions. Current reasoning and psychometric practice common in the scientific literature on personality assume that questionnaire items, and facet scores defined on them, reflect a common latent variable. This makes items exchangeable psychometric indicators of facets, and facets exchangeable indicators of a superordinate personality domain. We have mounted empirical evidence to show that, at least for the conscientiousness construct, this assumption may be mistaken. Facet scores showed divergent and theoretically plausible associations with working memory and self-control. This suggests that distinguishing between personality subdomains may be more important than several personality researchers have hitherto assumed.

To conclude, the combination of different assessment and data analysis methods documents differential relationships of conscientiousness facets. The results obtained are encouraging and suggest that such multimethod approaches might be useful for investigating personality factors other than conscientiousness. Considering the facet level rather than the global level might help to shed new light on the underlying mechanisms of personality.

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SUPPORTING INFORMATION

Supporting information may be found in the online version of this article at publisher's web site.

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