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Review

The hierarchical structure of self-reported impulsivity

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ABSTRACT

The hierarchical structure of 95 self-reported impulsivity items, along with delay–discount rates for money, was examined. A large sample of college students participated in the study ($N = 407$). Items represented every previously proposed dimension of self-reported impulsivity. Exploratory PCA yielded at least seven interpretable components: Prepared/Careful, Impetuous, Divertible, Thrill and Risk Seeking, Happy-Go-Lucky, Impatiently Pleasure Seeking, and Reserved. Discount rates loaded on Impatiently Pleasure Seeking, and correlated with the impulsiveness and venturesomeness scales from the I_7 (Eysenck, Pearson, Easting, & Allsopp, 1985). The hierarchical emergence of the components was explored, and we show how this hierarchical structure may help organize conflicting dimensions found in previous analyses. Finally, we argue that the discounting model (Ainslie, 1975) provides a qualitative framework for understanding the dimensions of impulsivity.

1. Introduction

In common usage to act *impulsively* can mean a variety of things. It can mean acting with little deliberation. It can mean giving in to the temptation to eat a fattening dessert. It can mean going skydiving. It can mean shouting when angry. The richness of such usage suggests that impulsivity is a multi-dimensional construct, and uncovering its structure presents substantial challenges to investigators interested in impulsivity. Much of this usage appears to be organized around a fairly small number of dimensions, but there is considerable disagreement over the number of dimensions and precisely what those dimensions may be. In the present study we examined the hierarchical interrelationships among dimensions of self-reported impulsivity, and our results suggest that despite the variety of reported dimensions there is greater agreement in the literature than at first appears. We also show that the delay–discount rate—a measure of the weight that a person assigns to future consequences—is related to at least one dimension of self-reported impulsivity.

The first goal of this study was to examine the component structure of a comprehensive set of self-report impulsivity items using a procedure that shows how components emerge as the number of components is increased (Goldberg, 2006). Rather than aiming to uncover the "right number" of components, this procedure instead focuses on showing the hierarchical relationships between component structures with differing numbers of components. We did not enter this research with strong hypotheses regarding the outcome, but our general hypothesis was that many of the dimensions of impulsivity reported in the literature were related hierarchically in a manner that was not apparent in most previous analyses.

The number of proposed dimensions of impulsivity ranges from 2 (e.g., Dickman, 1990; Eysenck et al., 1985) to 15 (Gerbing, Ahadi, & Patton, 1987). This disparity plausibly can be attributed to differences in the measurement instruments that are used (Parker & Bagby, 1997). In particular, the number and types of dimensions that arise in component analyses of self-report items is sensitive to the particular sets of items that are included. One can identify only those dimensions for which one has a sufficient number of relatively dimension-specific items. Thus, even items that are relevant to impulsivity may fail to load on any component in an analysis because they represent dimensions of impulsivity that are poorly represented, leading to underestimates of the number of dimensions. Conversely, including several items that are very similar to each other can yield essentially item-specific factors, and lead to overestimates of the number of dimensions. The observed dimensionality may vary across studies due to either or both aspects of item selection.

The second goal of this research was to position delay–discount rates within this hierarchical structure. *Delay discounting* refers to the reduction in the present value of a delayed reward as the delay to that reward increases. According to the discounting model of impulsiveness, impulsive choices arise because of the way the relative present values of delayed rewards change with the passage of time (Ainslie, 1975, 2001). Fig. 1 depicts the declining present values of two rewards available at two different future points in time. Time moves left to right in the figure. The vertical line at point *S* indicates the magnitude of a smaller, sooner reward, and the thin

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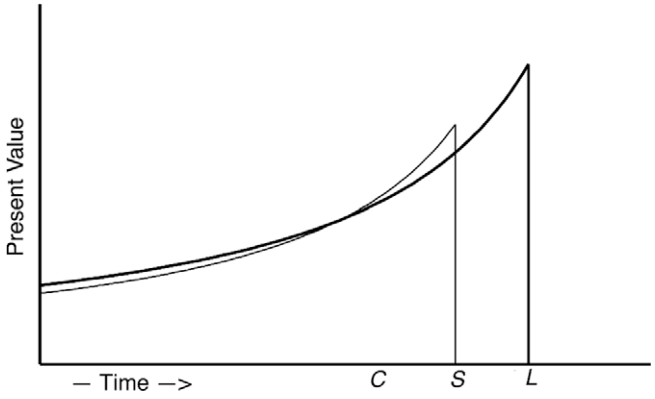

Fig. 1. Delay–discounting curves indicating the present values of a smaller, sooner reward available at time *S* (thin curve) and a larger, later reward available at time *L* (thick curve). At sufficiently long delays to both rewards (i.e., to the left of the crossover at *C*) the larger reward is preferred. Between times *C* and *S* the smaller reward is preferred, and if given an opportunity to choose during this interval this person may impulsively choose the smaller reward.

curve leading up to this point from the left shows how the present value of the reward increases as the delay to the reward decreases. Similarly, the vertical line at point *L* indicates the magnitude of a larger, later reward, and the thick curve shows how the present value of that reward increases as the delay to the reward decreases. At sufficient delays to both rewards, that is, all points in time to the left of the crossover *C*, this person prefers *L* over *S*. However, due to the (hyperbolic) form of the function by which rewards are discounted, as time passes through point *C* preference reverses such that the person prefers *S* over *L*. Thus, the interval between *C* and *S* is a "window of vulnerability" during which opportunities to choose between the rewards may result in choice of *S*. A choice of *S* within this window is defined as *impulsive*, whereas a choice of *L* is *self-controlled* (Rachlin, 2000). Research has shown that preferences often do reverse in this manner (Kirby & Guastello, 2001; Kirby & Herrnstein, 1995), and other major properties of this model have been confirmed experimentally in both animals and humans (for reviews see Green & Myerson, 2004; Kirby, 1997).

The individual's *discount rate* determines the steepness of the reduction in present value of delayed rewards. As the discount rate increases, the duration of the window of vulnerability increases, as does the strength of preference for the impulsive choice within the window. Thus, as discount rates increase people will tend to choose more immediate over future rewards, leading to greater impulsivity. Consistent with this prediction, substance abusers have been found to have higher discount rates, on average, than non-drug-users (Kirby & Petry, 2004; Kirby, Petry, & Bickel, 1999), smokers have higher discount rates than nonsmokers (Audrain-McGovern et al., 2004; Odum, Madden, & Bickel, 2002), and pathological gamblers have higher discount rates than controls (Petry, 2001). Discount rates are also correlated with impulse buying (Dittmar, 2001), attention deficit hyperactivity disorder (Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001), and possibly obesity (Komlos, Smith, & Bogin, 2004). Discount rates are negatively correlated with college grade point average (Kirby, Winston, & Santiesteban, 2005) and educational achievement (Kirby et al., 2002), and are a better predictor of adolescent academic performance than IQ (Duckworth & Seligman, 2005). Finally, discount rates correlate reliably with self-reported impulsivity (Kirby & Petry, 2004; Kirby et al., 1999), in the .2 to .3 range that is typically observed between behavioral and self-report measures (Gerbing et al., 1987; White et al., 1994). Thus, the discount rate has acquired some external validity as an index of at least some types of impulsivity. Discount rates as individual difference measures are relatively stable over time, with 1-year test–retest stabilities in the .7 range (Kirby, 2009).

However, Reynolds, Ortengren, Richards, and de Wit (2006) found no reliable association between their discount rate measure and several impulsivity scales. Our study differs from theirs in that we tested a large enough number of participants to allow principal components analysis (PCA) at the item, rather than scale, level. This allowed us to assess the relationships between discount rates and self-report impulsivity items without assuming that existing self-report scales are unidimensional. We believe ours to be the first study to conduct item-level PCA on a comprehensive set of impulsivity items including a measure of delay–discount rates.

2. Methods

2.1. Participants

The inventory was completed by 407 participants at three locations: University of Massachusetts at Amherst ($n = 64$), Massachusetts College of Liberal Arts ($n = 68$), and Williams College ($n = 275$). Of those who identified gender, 200 were women and 186 were men. Ages ranged from 17 to 55 years, with a mean of 20.7 ($SD = 4.8$). Approximately 100 of the Williams College students were enrolled in an introductory psychology course and received course credit. They were tested in scheduled group sessions with 10–40 participants. The remaining participants were recruited at tables in the lobbies of student centers at the three schools, and were tested individually. Most of these participants were college students, but non-students were also allowed to participate at each location. All participants were informed prior to consenting to participate that they would each have a chance of winning a cash award ranging from $8 to $80, with the amount depending on their choices in the task.

2.2. Materials and procedure

2.2.1. Self-report impulsivity items

To cast our net widely, we included impulsivity items from nine major inventories, as well as other items that seemed to represent impulsive behavior, such as items relating to gambling, sex, drugs, and alcohol. We first examined all items' loading values in previously published factor analyses (Barratt, 1965, 1985; Corulla, 1987, 1988; Eysenck & Eysenck, 1977, 1978; Eysenck & McGurk, 1980; Eysenck et al., 1985; Gerbing et al., 1987; Luengo, Carrillo de la Pena, & Otero, 1991; Parker, Bagby, & Webster, 1993; Patton, Stanford, & Barratt, 1995; Zuckerman, 1994). Taking sample size in each study into account, we then selected items whose loadings in at least one study were statistically significant (Stevens, 1992). The I_7 *Impulsiveness* (IMP) and *Venturesomeness* (VENT) scales were included in their entirety (Eysenck & Eysenck, 1977, 1978; Eysenck & McGurk, 1980; Eysenck et al., 1985). Finally, we eliminated all but one of each subset of items whose content appeared redundant (e.g., "I am impulsive" and "I am an impulsive person") by selecting the item that had performed best in previous factor analyses, except when one of the items was from the I_7, in which case its wording was retained. The list of sources and the final number of items drawn from each is shown in Table 1.

Our inventory was arranged in four sections based on response format. Items retained the same format as the questionnaires from which they originated, with the exception of the SSS items, which were modified to fit a yes/no format. The first page contained the I_7 items plus one I_5 item. Participants answered these questions by putting a circle around 'yes' or 'no.' The second page contained the *PRF*, *SSS*, *GZTS*, *MPQ*, *MMPI* and *EASI* items. Participants marked 'yes' if the statement seemed to be true or they agreed with it, and

Table 1
Sources of self-report impulsivity items.

Scale	Source	# of items used
Barratt Impulsiveness Scale (BIS-8)	Barratt and Patton(1983)	5
Barratt Impulsiveness Scale (BIS-11)	Patton et al. (1995)	17
EASI Temperament Survey, III	Buss and Plomin (1975)	1
Guilford–Zimmerman Temperament Survey (GZTS) Restraint and General Activity Scales	Guilford, Guilford, and Zimmerman (1978)	11
I_5 Questionnaire	Eysenck and McGurk (1980)	1
I_7 Questionnaire	Eysenck, Pearson, Easting, and Allsopp (1985)	35
Minnesota Multiphasic Personality Inventory (MMPI)	Hathaway and McKinley (1967)	1
Multidimensional Personality Questionnaire (MPQ) Control vs. Impulsivity Scale	Tellegen (1982)	12
Personality Research Form (PRF) Impulsivity Scale	Jackson (1974)	6
Sensation Seeking Scale (SSS)	Zuckerman (1994)	5
16 Personality Factors (16PF) Questionnaire Impulsivity (surgency) scale	Cattell, Eber, and Tatsuoka (1970)	1

'no' if the statement was more false than true or they disagreed with it. The third page contained the *BIS-8*, *BIS-10*, and *16PF* items. The self-report items on this page required responses on a 1-to-4 scale indicating how well the statement described the participant, where 1 was *rarely/never*, 2 was *occasionally*, 3 was *often*, and 4 was *always/almost always*.

2.2.2. Discount rate measure

The third page also included the monetary choice questionnaire (MCQ), which is one of the best validated discount rate measures (Duckworth & Seligman, 2005; Kirby, 2009; Kirby & Petry, 2004; Kirby et al., 1999). Table 2 shows the values used for the nine monetary choice questions that were used to assess discount rates. For each item participants were asked to choose between a smaller, immediate amount (S) and a larger, later amount (L). For example, for the item in the top row of Table 2 participants were asked "Would you prefer (a) $78 today or (b) $80 in 162 days?" Discount rates were estimated from the pattern of choices that participants made across the nine questions. This procedure is described in detail elsewhere (Kirby et al., 1999). Briefly, delay–discounting curves can be described quite well by the following hyperbolic equation (Mazur, 1987):

$$V = \frac{A}{1 + kD}, \tag{1}$$

where V is the present value of the outcome A at delay D, and k is the discount rate parameter. For each question in Table 2 we can solve for the value of k that would yield indifference between the immediate and the delayed reward. These values are shown in the last column of Table 2. A person who chooses the immediate reward reveals a discount rate for the delayed reward that is greater than the indifference value, whereas a person who chooses the delayed reward reveals a discount rate less than the indifference value. Thus, a participant's pattern of choices across the nine items allows us to put bounds on the participant's discount rate.

Table 2
Monetary choice items and their associated discount rates at indifference.

Item #	Reward values			k
	Immediate	Delayed	Delay	
3	$78	$80	162	0.00016
6	$80	$85	157	0.0004
4	$67	$75	119	0.001
5	$69	$85	91	0.0025
1	$55	$75	61	0.006
9	$54	$80	30	0.016
8	$41	$75	20	0.041
7	$33	$80	14	0.1
2	$31	$85	7	0.25

Note. k is the hyperbolic delay–discounting rate parameter from Eq. (1) that yields indifference between the immediate and the delayed rewards. All delays are in days.

Because participants' choices are not always perfectly consistent with a single value of k, we computed the proportion of each participant's choices that were consistent with assignment to each of the 10 values of k defined by the questionnaire. We then assigned each participant the k that yielded the highest consistency among his or her choices. Participants who chose all nine immediate or delayed rewards were assigned the value of k corresponding to the endpoints of our measure. This procedure succeeded in assigning k values such that, on average, 99% of each participant's choices were consistent with the assigned rate. For analysis the distributions of k were approximately normalized using the natural log transformation.

2.2.3. Reward selection

To permit assessment of discount rates for real rewards, and to provide an incentive to take each choice seriously, all participants were given a chance to win a reward that was based on their MCQ choices. Participants who were tested individually were given a 1-in-20 chance to win money (by roll of a 20-sided die). For participants tested in groups, one money winner was randomly chosen from each group. Each winner then rolled a 9-sided die to select one of the nine MCQ items, and received the reward that he or she chose on that item. All rewards were paid in cash at the delay specified.

2.3. Analyses

2.3.1. Polychoric correlations

PCA and factor analyses assume that the joint distributions of items in the analyses are multivariate normal (Gorsuch, 1983). This assumption is badly violated with dichotomous and Likert-scale response formats such as those used here. Thus, we performed analyses on the matrix of pairwise polychoric correlations between items, on the assumption that our categorical items are proxies for underlying continuous normal distributions that are cut at one or more thresholds. To obtain polychoric correlations, the joint distributions among pairs of variables are used to estimate these thresholds, and then an estimate of the correlation between the underlying continuous variables is computed (Panter, Swygert, Dahlstrom, & Tanaka, 1997).

The polychoric correlations were computed in Stata 9.2 using the *Polychoric* package (Kolenikov, 2004). As often happens, the resulting polychoric correlation matrix was not positive definite due to the presence of negative eigenvalues (Wothke, 1993). To remedy this, we set all negative eigenvalues to a small positive constant (0.01), and then recomposed the new positive definite polychoric correlation matrix.

To help ensure that this procedure did not lead to artifacts, all analyses were repeated using the Pearson (raw item) correlation

matrix. No meaningful differences emerged, so only the results using the polychoric correlations are reported below.

2.3.2. Principal components analyses (PCA)

To ensure that the components that we selected for interpretation were not sensitive to the method of analysis, we repeated the analyses using a variety of procedures (Steger, 2006). For both the polychoric and Pearson correlation matrices we performed PCAs with orthogonal rotation (varimax) and oblique rotation (promax with $\kappa = 3$, Tataryn, Wood, & Gorsuch, 1999). All of these analyses resulted in nearly identical component structures, with differences emerging mainly in the locations of the highest loadings of a small number of items that loaded similarly on multiple components. The interpretations of our components were not sensitive to the method used to extract them. Only the PCA with varimax rotation is reported below.

2.3.3. Hierarchical component emergence

Goldberg (2006) describes a method for examining the hierarchical structure of a set of items that does not require deciding in advance the number of components to extract. Different numbers of components are viewed as representing different levels of abstraction, and we examine all levels of abstraction down to the lowest level that yields meaningful components. The correlations between component scores at adjacent levels of abstraction provide information on how the components at each level are related to components at higher and lower levels. This information is summarized in a component emergence diagram, which is described below.

2.3.4. Number of dimensions

In evaluative simulations, Horn's (1965) parallel analysis (PA) procedure and Velicer's (1976) minimum average partial (MAP) correlation test have been found superior to traditional procedures (e.g., scree plots and eigenvalues > 1) for determining the appropriate number of components to extract (Velicer, Eaton, & Fava, 2000; Zwick & Velicer, 1986). When they err, MAP tends to recommend too few components and PA too many. Thus, the use of both offers guidance in deciding on the appropriate number of components (Goldberg & Velicer, 2006; O'Connor, 2004). We used SPSS programs by O'Connor (2004) to perform both tests.

Because our goal is to explore the hierarchical relationships between component structures with differing numbers of components, in the results below we err on the side of reporting extractions with what some readers may consider too many components, including some that are uninterpretable, conceptually ambiguous, or represented by few items. We do this in case the weakness of one or more or those components is due to inadequate representation of its content in our set of items (Goldberg, 2006). One advantage of the hierarchical method employed here is that, because the lower order solutions are displayed as well, displaying solutions with too many components does little harm. It may, however, provide clues for future researchers who wish to explore those poorly defined components.

3. Results

3.1. Number of dimensions

For the polychoric matrix the MAP test yielded a minimum at 5 components, and the PA procedure suggested extracting 14. For the

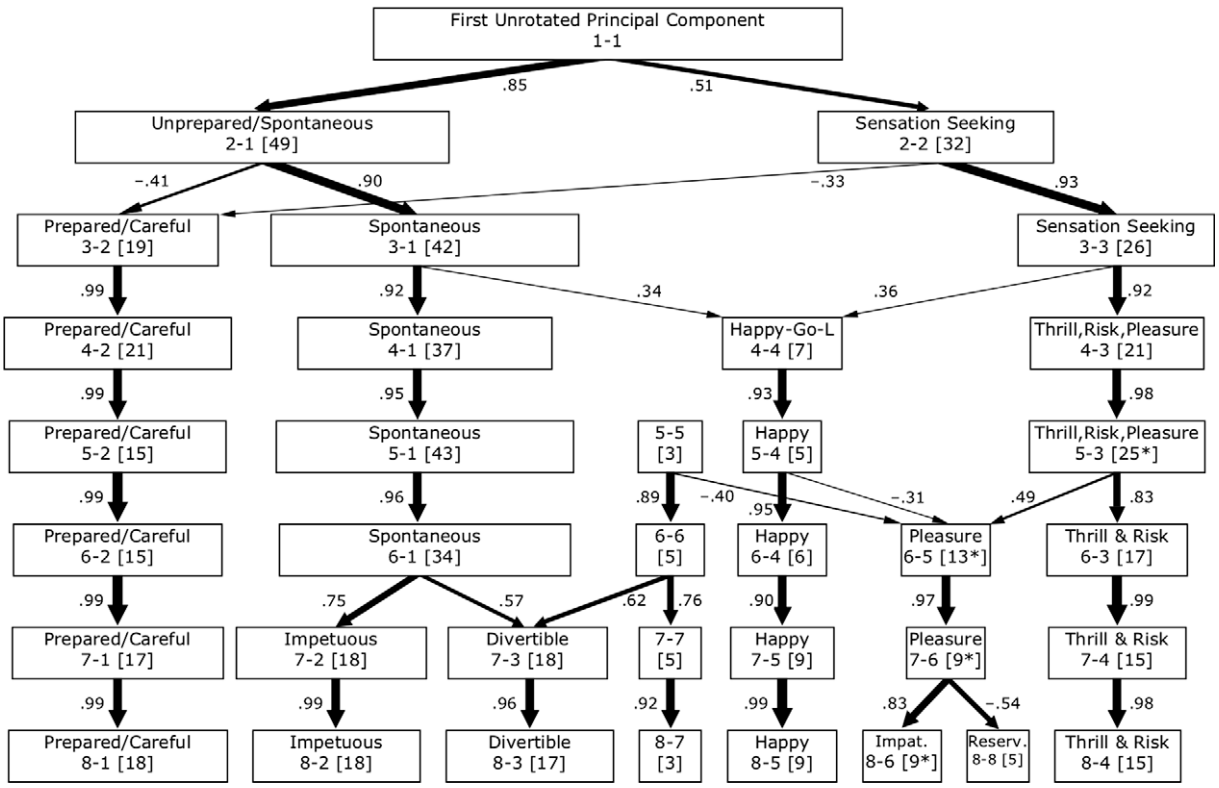

Fig. 2. Component emergence diagram for extractions up to eight components. The numbering notation is *level-component*: For example, 2-1 represents the 1st (largest) component in the 2-component extraction. Box width corresponds to the proportion of variance accounted for. Arrow labels and thicknesses show correlations larger than .30 between the component scores at adjacent levels of extraction. The number of items with loadings over .30 whose highest loading was on the component is shown in brackets. Asterisks indicate components on which discount rates (k) loaded above .30.

Pearson matrix the MAP test yielded a minimum at seven components, and the PA procedure suggested extracting nine. Thus, for both matrices the midpoint of the two methods was approximately eight components. Eight was also the largest number of components that could be extracted such that all components had more than two items loading above .30. Thus, we describe extractions up to eight components below. This does not imply the eight is the "right number" of impulsivity dimensions, but rather that eight is the largest number that was adequately represented in our questionnaire. Nor does it imply that all eight of these components are stable and reliable: most traditional stopping rules for component extraction would yield solutions with fewer than eight components. We report the eight component extraction for the reasons described above.

3.2. Component emergence

Fig. 2 shows the component emergence diagram (Goldberg, 2006) for extractions ranging from one to eight components. This diagram shows the relationships between components at different levels of extraction. The first principal component is at the top. The remainder are rotated components. The notation "2-1," for example, represents the largest component in the two-component extraction. The width of each rectangle corresponds to the proportion of variance accounted for by that component. The labeled arrows show the correlations between the component scores at adjacent levels of extraction. Only correlations larger than .30 are depicted. The number of items with loadings over .30 whose highest loading was on the component is shown in brackets.

The items that loaded on each of the eight components at the bottom of Fig. 2 are shown in Table 3. We have included items in the table that loaded on multiple components to signal relationships among the dimensions, and to aid future researchers in scale construction.

As depicted in Fig. 2, the first component (1-1) split into components corresponding roughly to items with themes of being Unprepared/Spontaneous (2-1) and Sensation Seeking (2-2). At the third level these two components were largely preserved, but the third component (3-2) pulled away items relating to preparedness that had loaded on 2-1 and items pertaining to planning and future orientation that had loaded on 2-2. This new component, which we called *Prepared/Careful*, remained stable through all subsequent extractions.

Moving from level 3 to level 4, the Spontaneous and Sensation Seeking components again contributed items to a new component (4-4), which we labeled *Happy-Go-Lucky*. This component remained stable through all subsequent extractions. The sensation seeking items that remained on 4-3 were more narrow than those on 3-3, and centered around themes of thrill, risk, and hedonic pleasure seeking.

All four components at level four were preserved at level five. The new component 5-5 contained five items, but only the first three of these had loadings above .30. This component and those directly below it in Fig. 2 were neither stable nor interpretable. At level six the items from 5-5 were joined by two others to make 6-6, but at the next level the highest four of these jumped to 7-3 and remained together at level 8-3 (see Table 3). The remaining items from 5-5 ended up on 6-6, 7-7, and 8-7.

Returning to level six, a new component (6-5) emerged that was related to several components at level five. This component picked up six items from 5-1 and seven items from 5-3, most of which involved hedonic pleasure or avoidance of boredom. We labeled it *Pleasure Seeking*. The remaining items on 6-3 (including nearly all of the I_7 *VENT* items) related to thrill and risk seeking. We labeled it *Thrill and Risk Seeking*.

From level six to level seven the most important change was the split in the Spontaneous component (6-1). The first (7-2) included items that relate to spontaneous, careless, or unreflective decisions and actions. We called this component *Impetuous*. The second (7-3) included items mainly relating to lack of perseverance in tasks and lack of concentration. We chose to call this component *Divertible* rather than the more common "distractible" because the latter tends to connote changes of attention over short time spans, whereas the items on 7-3 also involved changes of interest over longer time spans.

From levels seven to eight all components were retained, with the exception of 7-6, which split into 8-6 and 8-8. Component 8-6 contained items relating to impatience with boredom and enjoyment of hedonic pleasure. No single term captures all of these items well, but we have called it *Impatiently Pleasure Seeking* because a majority of items seemed to imply impatience with the deferral of hedonic experience. This was the component on which the delay–discount rate k loaded most highly. Component 8-8 contained items relating to diffidence with respect to drinking, sex, and parties, and we labeled it, for want of a better term, *Reserved*.

We examined extractions up to 14 components. Although most of the additional components contained too few items for identification, there were three changes that deserve mention: (a) risk seeking items separated from thrill seeking items to form their own component, (b) the items on our Divertible component split into separate components for changing interests and distractibility, and (c) our Impatiently Pleasure Seeking component further fragmented: the merriment and sex items moved to the Reserved component, and a new component captured the "illegal" and drug items.

3.3. Discount rates

Components on which k loaded above .30 at each level are denoted by asterisks in Fig. 2. The loadings for k on all components at level eight are shown in the last row of Table 4. As noted above, at level eight, k loaded above .30 only on Impatiently Pleasure Seeking (8-6). Discount rates were reliably correlated with the I_7 IMP ($r = .22$) and VENT ($r = .21$) scales, $p < .001$. These values are roughly consistent with the corresponding values (.27 and .19, respectively) using the I_5 found in Kirby et al. (1999), and are in the .2 to .3 range that is typically observed between behavioral and self-report measures (Gerbing et al., 1987; White et al., 1994). We have no explanation for why Reynolds et al. (2006) found much smaller correlations between k and the I_7 scales.

4. Discussion

4.1. Relations to previous dimensions

It is beyond the scope of this paper to compare each of our components with previous component analyses. However, one advantage of the hierarchical approach represented by the component emergence diagram in Fig. 2 is that it may help organize the variety of impulsivity dimensions that have been reported in previous research. We briefly illustrate this using the I_7 and *BIS-11* scales.

4.2. The I_7

Of the 19 items on the I_7 IMP scale, 17 loaded on our Unprepared/Spontaneous (2-1). Of the 16 items on the I_7 VENT scale, 15 loaded on our Sensation Seeking (2-2). Thus, our two-component extraction yielded components roughly consistent with the I_7 scales. However, at lower levels of abstraction the IMP scale items separated, such that by the eighth level they loaded primarily on Impetuous

Table 3
Items with loadings >.30 on the eight component extraction with PCA (varimax rotation).

No.	Scale	Items	Loadings	Other
Component 8-1: Prepared/Careful			(α = .85)	
57	MPQ	I plan and organize my work in detail	.79	
54	EASI	I like to plan things way ahead of time	.77	
92	BIS-11	I plan tasks carefully	.69	
50	MPQ	People say that I am methodical (that I do things in a systematic manner)	.67	
95	BIS-11	I am future oriented	.66	
51	MPQ	I generally do not like to have detailed plans	−.64	
44	GZ-R	I take life very seriously	.63	
36	I_5	When you go on a trip, do you like to plan routes and timetables carefully?	.62	
70	GZ-R	Many of my friends think I take my work too seriously	.60	
61	MPQ	I don't like to start a project until I know exactly how to proceed	.58	
80	BIS-11	I am more interested in the present than the future	−.56	
73	BIS-11	I plan for job security.	.54	
58	MPQ	I am very level-headed and always like to keep my feet on the ground	.51	
55	MPQ	Before I get into a new situation I like to find out what to expect from it	.51	
90	BIS-11	I am a careful thinker	.46	2,7
65	GZ-R	I am so concerned about the future that I do not get as much fun out of the present as I might	.46	5
82	BIS-11	I am self-controlled.	.40	2,3
79	BIS-11	I walk and move fast.	.33	2
Component 8-2: Impetuous			(α = .87)	
35	I_7-I	Do you usually make up your mind quickly?	.67	
88	BIS-8	I answer quickly.	.66	
48	PRF	I often say the first thing that comes into my head.	.64	3
06	I_7-I	Do you generally do and say things without stopping to think?	.61	3
12	I_7-I	Do you usually think carefully before doing anything?	−.59	1,3
45	MPQ	I like to stop and think things over before I do them.	−.59	1
33	I_7-I	Do you often prefer to "sleep on it" before making decisions?	−.58	
40	PRF	Many of my actions seem to be hasty.	.56	3
28	I_7-I	Do you usually work quickly, without bothering to check?	.55	
34	I_7-I	When people shout at you, do you shout back?	.55	
47	MPQ	I am more likely to be fast and careless than to be slow and plodding.	.54	5
81	BIS-11	I do things without thinking.	.51	1,3
41	PRF	I generally rely on careful reasoning when making up my mind.	–.50	1,3
15	I_7-I	Do you mostly speak without thinking things out?	.48	3
30	I_7-I	Before making up your mind, do you consider all the advantages and disadvantages?	−.47	1
49	MPQ	I am often not as cautious as I should be	.42	3
66	GZ-R	I often stop to analyze my thoughts and feelings	−.39	7
20	I_7-I	Do you need to use a lot of self-control to stay out of trouble?	.33	3,4
Component 8-3: Divertible			(α = .80)	
16	I_7-I	Do you often get involved in things you later wish you could get out of?	.68	
38	PRF	Sometimes I get several projects started at once because I don't think ahead	.65	
64	GZ-R	I have a habit of starting things and then losing interest in them	.60	
75	BIS-11	I concentrate easily	−.56	
72	PRF	Often I stop in the middle of one activity in order to start something else	.55	7
07	I_7-I	Do you often get into a jam because you do things without thinking?	.54	2
29	I_7-I	Do you often change your interests?	.52	
17	I_7-I	Do you often get so carried away by new and exciting ideas that you never think of possible snags?	.51	
85	BIS-8	I complete what I start	−.51	1
76	BIS-11	I often have extraneous thoughts when thinking	.48	7
89	BIS-8	I buy things that I don't need	.47	6
74	BIS-11	I don't pay attention	.45	1
05	I_7-I	Do you often buy things on impulse?	.42	5,6
68	MPQ	I often like to do the first thing that comes to my mind	.41	2,5
93	BIS-11	I have "racing" thoughts	.41	
23	I_7-I	Are you often surprised at people's reactions to what you do or say?	.39	
77	BIS-11	I squirm at plays or lectures	.30	8
Component 8-4: Thrill and Risk Seeking			(α = .78)	
04	I_7-V	Would you enjoy skydiving?	.66	
01	I_7-V	Would you enjoy water skiing?	.63	
26	I_7-V	Would you like to go scuba diving?	.62	
31	I_7-V	Would you like to go four-wheeling? [replaced I_7-V "pot-holing"]	.61	
19	I_7-V	Do you sometimes like doing things that are a bit frightening?	.58	7
03	I_7-V	Do you enjoy taking risks?	.56	
24	I_7-V	Would you enjoy the sensation of skiing very fast down a high mountain slope?	.55	
09	I_7-V	Do you like diving off the high board?	.53	
13	I_7-V	Would you like to learn to fly an airplane?	.53	
11	I_7-V	Do you welcome new and exciting experiences and sensations, even if they are a little frightening and unconventional?	.49	5

(*continued on next page*)

Table 3 (*continued*)

No.	Scale	Items	Loadings	Other
56	MPQ	I almost never do anything reckless	−.49	1
27	I_7-V	Would you enjoy fast driving?	.46	
84	BIS-8	I take chances	.44	5
32	I_7-V	Would you be put off a job involving quite a bit of danger?	−.41	
08	I_7-V	Do you think hitch-hiking is too dangerous a way to travel?	−.41	1
Component 8-5: Happy-Go-Lucky			(α = .77)	
71	GZ-R	I am a happy-go-lucky individual.	.73	
86	16PF	I am considered a very enthusiastic person.	.67	
67	GZ-G	People think I am a very energetic person.	.61	
63	GZ-R	I am a carefree individual.	.60	
52	MPQ	People consider me a rather freewheeling and spontaneous person.	.56	1
14	I_7-I	Do you often do things on the spur of the moment?	.51	1,3
10	I_7-I	Are you an impulsive person?	.47	2,3
87	BIS-8	I take dares just for fun.	.46	4
83	BIS-11	I act "on impulse."	.45	1,2,3
Component 8-6: Impatiently Pleasure Seeking			(α = .53)	
21	I_7-I	Would you agree that almost everything enjoyable is illegal or immoral?	.56	3
43	SS S	I have no patience with dull or boring persons	.54	
53	MM PI	I easily become impatient with people	.47	
42	SS S	A person should have considerable sexual experience before marriage	.44	8
62	GZ-R	I believe in the idea that we should "eat, drink, and be merry, for tomorrow we die"	.42	5,8
60	GZ-R	I am fond of betting money on games and other events.	.42	7
96–104	MCQ	*k* (delay–discount rate parameter from Eq. (1))	.40	
39	SS S	I would not like to try any drug which might produce strange and dangerous effects on me	−.36	4
94	BIS-11	I save regularly	−.30	
Component 8-7			(α = .15)	
18	I_7-V	Do you find it hard to understand people who risk their necks climbing mountains?	−.48	4
91	BIS-11	I like to think about complex problems.	.44	
02	I_7-V	Do you usually prefer to stick to brands you know are reliable, over trying new ones on the chance of finding something better?	−.37	
Component 8-8: Reserved			(α = .40)	
46	SS S	Heavy drinking usually ruins a party because some people get loud and rowdy	.67	
59	SS S	I dislike people who are uninhibited and free about sex	.52	
69	GZ-R	I like parties I attend to be lively	–.37	
37	PR F	Emotion seldom causes me to act without thinking	.36	
22	I_7-V	Generally do you prefer to enter cold water gradually, over diving or jumping straight in?	.34	

Note. α, Cronbach's coefficient alpha for the items loading on the component. The "Other" column shows other components on which the item loaded >.30.

Table 4
Loadings on the Eight-component solution for items with high face validity, and the discount rate (*k*).

Item	Component							
	8-1	8-2	8-3	8-4	8-5	8-6	8-7	8-8
Are you an impulsive person?	−.28	.39	.43	.17	.47	.14	.09	.13
I act "on impulse."	−.30	.39	.41	.15	.45	.07	.18	−.03
I am self-controlled.	.40	−.35	−.33	−.01	−.02	.05	.12	.13
Do you need to use a lot of self-control to stay out of trouble?	.05	.33	.32	.30	.05	.18	−.12	.29
k	−.10	.13	−.01	.17	.09	.40	−.08	−.08

(8-2) and Divertible (8-3). The VENT items mostly stayed together on our Thrill and Risk Seeking component (8-4), although as we mentioned above, there is some evidence that these items may be separable into distinct Thrill and Risk components. In summary, we replicated the I_7's dimensions, and by positioning them in a hierarchical structure we can see that they represent a relatively high level of abstraction.

4.3. The BIS-11

Patton et al. (1995) conducted an oblique PC analysis of the items on the *BIS-11*. Their analysis identified six first-order components, organized in pairs under three second-order components. There was substantial overlap between their components and those that emerged in our analysis, but the correspondences occurred at various levels of the two hierarchies. In some instances we were able to identify components at lower levels of abstraction. For example, Patton et al.'s (1995) first-order Motor Impulsiveness component contained items that loaded separately on our Impetuous, Divertible, and Happy-Go-Lucky components. All but one of these items loaded on our more abstract Spontaneous (3-1) component, which combined these three lower-level components. Thus, the first-order Motor Impulsiveness component corresponded approximately to our Spontaneous (3-1). In other instances Patton et al. were able to identify components at lower levels of abstraction. For example, our Divertible component included items that loaded on Patton et al.'s second-order Attentional Impulsiveness. However, in Patton et al.'s data these items loaded onto separate first-order components (Attention, Cognitive Instability), which suggests that our Divertible component is at a higher level of abstraction than those first-order components.

It is well known that the particular components that emerge in any analysis can depend on the particular set of items that are included. What this brief discussion shows is that the development of top-down hierarchical component structures (Goldberg, 2006), like that in Fig. 2, may reveal more agreement among different analyses than at first appears, and help organize what might otherwise remain a "confusing marketplace of results" (Steger, 2006).

The component loadings in Table 3, along with the structure shown in Fig. 2, can guide researchers in identifying the most promising items for future scale construction. Subsets of items might be used to measure dimensions of impulsivity at any level of the hierarchy in Fig. 2. Items with low loadings, or with loadings on multiple components, might be dropped, and new items that are hypothesized to better represent the component might be added. The relatively low loadings and Cronbach αs for components 8-6 and 8-8 indicate—assuming they represent replicable dimensions—that those components would benefit from the addition of new and more dimension-specific items.

4.4. The problem of redundant items

As we mentioned in Section 1, Gerbing et al. (1987) identified 15 impulsivity dimensions, nearly double the number indentified in this study. Gerbing et al. analyzed a large number (378) of impulsivity items from several questionnaires, along with four behavioral tasks. Their analysis identified 3 behavioral and 12 self-report first-order factors. Six of our eight components had approximate counterparts in Gerbing et al.'s twelve. The two that did not were 8-7, which was uninterpretable, and Reserved (8-8), which contained items not included in their questionnaire.

What of Gerbing et al.'s (1987) other self-report factors? Nine of their 12 factors were composed of only three items, which is the minimum that is typically recommended for factor identification (Anderson & Gerbing, 1984). For at least five of those factors two or three of the three items were simple rewordings of each other. For example, their *Restless* factor contained the items "I am restless at the theatre or lectures," "I squirm at plays or lectures," and "I am restless at lectures." (We included only the second of these on our questionnaire, and it loaded +.30 on our Divertible component and −.30 on our Reserved component.) The problem with using redundant items as though they are different variables is that they can be more highly correlated with each other than they are with any underlying personality dimension. This can have the effect of pulling apart the underlying dimensions, and giving the appearance that the underlying structure has more psychologically meaningful dimensions that it actually does.

We believe it likely that some of the microstructure that Gerbing et al. (1987) identified was an artifact of repeating items, and does not reveal psychologically meaningful microstructure of impulsivity. Thus, more evidence is needed to determine which of their factors correspond to separate dimensions of impulsivity. Our suggestion is that when items are highly similar one should count them as a single item towards the minimum of three items required to identify a factor. By this criterion several of Gerbing et al.'s factors fall short, but may represent important content that was poorly represented in the set of items (Goldberg, 2006). Indeed, we corroborated their *Quick Decisions* (our Impetuous) and Happy-Go-Lucky dimensions with a larger number of items. Future research may determine whether additional items can be found that will load on, for example, a separate Restless dimension.

4.5. Face-valid items

Items that are most clearly "impulsivity items" have sometimes been used to help define separate dimensions of impulsivity, but our hierarchical analysis suggests that such items tend to be relatively abstract, and not dimension specific. The four items with arguably the highest face validity in our inventory are shown in Table 4. Each of these items loaded above .30 on at least three of our components. Because of the imprecision of the term "impulsive" in everyday usage, participants' idiosyncratic readings of these items might tend to reduce their correlations with any single dimension. When answering "Are you an impulsive person?," it matters whether the person takes this to mean "Do you make up your mind quickly?," or "Are you happy-go-lucky?," or both. Conversely, to the extent that several components represent sub-dimensions of impulsivity, such a general question ought to be associated to some extent with each of those components. This problem may be hidden when the number of dimensions is greatly constrained (e.g., on the I_7) or when an "impulsive" dimension is defined primarily by redundant items (e.g., in Gerbing et al. 1987).

4.6. Reward attributes and the time scales of impulsivity

As noted above, our discount rate measure (k) was reliably correlated with the I_7 impulsiveness and venturesomeness scales, which represent relatively high levels of abstraction. At lower levels of abstraction (level 5 and below in Fig. 2), k loaded above .30 on individual components. The loadings for k on all components at level eight are shown in the last row of Table 4, where it loaded above .30 only on Impatiently Pleasure Seeking (8-6). However, we think it premature to conclude that discounting in general contributes to only one dimension of impulsivity. We estimated k only for monetary rewards in the tens of dollars, over time scales ranging from days to months. It is possible that both reward attributes and the time scale might limit the generality of the observed relationships in our study, and also provide one reason why behavioral and self-report measures of impulsivity typically correlate only in the .2 to .3 range. Here we briefly explain why we think this speculation is plausible.

4.7. Reward attributes

There is evidence that discount rates may vary across types of rewards (e.g., Estle, Green, Myerson, & Holt, 2007; Kirby & Guastello, 2001). For example, one person may be more impulsive for money than another person, but less impulsive for food. This would decrease the correlation between impulsiveness for the different reward types even if a common mechanism such as discounting underlay both. Second, discount rates tend to decrease as the magnitudes of the rewards increase, and individuals differ in the size of this magnitude effect (e.g., Kirby, 1997). A person with a large magnitude effect might be more impulsive than another person for small rewards, but less impulsive than that other person for large rewards. Such individual differences in the effects of reward attributes on discount rates would tend to reduce the correlation between the discount rates for a particular reward type and dimensions of self-reported impulsivity involving consequences of different types.

4.8. Time scales

Individual differences in observed discount rates may vary with the time scales of the delays to outcomes (see Ainslie, 2001, chap. 4). It is well established that the rate of decrease in the value of a reward decreases as the delay increases: This is the property captured by the hyperbolic discount function (Fig. 1) that allows discount functions to cross. Individuals may differ in this rate–delay relationship, as indexed by a second parameter in a hyperbola-like model (see Green & Myerson, 2004, for a review). Individual differences in the rate–delay relationship would tend to reduce the correlations between discount rates measured at one time scale and

self-reported impulsivity items with behavioral consequences that are realized at different time scales.

For example, "making up one's mind quickly" (component 8-2) and "getting involved in things you later wish you could get out of" (component 8-3) both might arise due to impulsive preference reversals as defined by the discounting model (see Fig. 1), but their time scales are quite different. Impetuous decisions involve implicit choices between the almost immediate termination of cognitive effort (on a time scale of fractions of a second) and the delayed benefits of more cautious reflection. A person who had relatively high discount rates at small time scales might be more likely to terminate that cognitive effort. In contrast, choosing whether or not to "get involved in things" typically means choosing between different delayed activities, where the time scale of the delays to the sooner reward (the new activity) is in minutes to days. A person with a relatively high discount rate for these longer durations might be more likely to choose the new activity, whether or not she made this choice quickly. The quickness of a decision does not in itself determine whether the person will choose the more or less impulsive alternative. As a consequence, these two items might load on different dimensions of impulsivity, even though they may both be defined by preference reversals due to delay discounting, as depicted in Fig. 1.

Thus, rather than being limited to a single dimension of impulsivity, we share Ainslie's (1975, 2001) view that preference reversal as a function of delay offers a plausible qualitative invariance across the dimensions of impulsivity, and arguably characterizes the essential nature of most of the phenomena to which the label "impulsivity" is customarily applied. One virtue of adopting this view is that it could provide a theoretical basis for excluding candidate dimensions of impulsivity. For example, dimensions such as Happy-Go-Lucky, which are not readily characterized by intertemporal preference reversals, may be more appropriately characterized as non-impulsivity dimensions.

4.9. Limitations

Two potential limitations are worth noting. First, most of our participants were college students. This may limit the generality of our results, and in particular it is possible that the restriction of range of some variables could obscure relationships that would appear in samples from a broader population. Second, budgetary constraints on payments for the monetary choice items and our desire to include an exhaustive set of items resulted in a 4-1 ratio of participants to items, which is lower than is typically recommended (Bryant & Yarnold, 1995). Fortunately, most of our components had high absolute loading magnitudes ("component saturations"), and thus exceeded more specific reliability criteria. Having either four or more items loading greater than 0.6, or 10 or more items loading greater than 0.4, predicts component reliability regardless of sample size (Guadagnoli & Velicer, 1988). As can be seen in Table 3, the first five components of our eight component structure met one or both of these criteria. Thus, sample size is a concern only for the last three components in the eight-component solution.

5. Conclusion

Much of the research on personality differences in impulsivity has been guided at least implicitly by the "lexical hypothesis," the proposal that our most important personality differences will have become encoded into our natural language (Goldberg, 1981; Goldberg & Velicer, 2006). The scientific usefulness of natural language terms, however, will be limited by the specificity with which words pick out categories of behavior based on common psychological etiology. Ultimately, it is important to motivate these categories with theoretical constructs that have independent support apart from their implications for impulsivity. There are several important examples of this in the impulsivity literature, including applications of the Five Factor Model of personality (McCrae & Costa, 2003; Whiteside & Lynam, 2001) and behavioral inhibition theories (Avila & Parcet, 2000; Gray, Owen, Davis, & Tsaltas, 1983; Patterson & Newman, 1993). We believe that the discounting model of impulsivity (Ainslie, 2001; Rachlin, 2000) offers an important framework for unifying these constructs, and that top-down hierarchical structures offer promise in helping to organize the relationships among them.

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