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Role of Working Memory Updating and Working Memory Capacity in Moderating the Relationship between Impulsivity with Propensity of Risk Taking Behaviors and Decision Making in Boy Adolescents

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Abstract

In this research, authors examine how individual differences in working memory capacity and Working Memory updating influence differences in impulsivity in risky decision making and behaviors. This study makes attempt to address extension of related works on the relationship between working memory, impulsivity and risky decision making and behaviors in adolescents. A large sample (420) of boy secondary grade students involved in this research; this study indicated that working memory capacity and updating Working Memory moderate some of impulsivity and high risk behaviors and decision making. Individuals with low working memory capacity and high impulsivity compared to individuals with high working memory capacity and high impulsivity are more likely subjected to risky decision making. Further, high risk behaviors are more salient in individuals with low updating Working Memory and high impulsivity.

Keywords: impulsivity, updating working memory, propensity, risky behaviors

1. Introduction

Risky behaviors during adolescence are higher than period before adulthood (Steinberg, 2007). The largest behavioral change witnessed in adolescence includes change in risky behaviors such as drug dependency, accidents, unprotected sex, violent behavior and delinquency (Betancourt, Giannetta, Brodsky, Farah, & Hurt, 2009; Romer, Duckworth, Sznitman, & Park, 2010). According to researchers, third fourth of mortalities at adolescence are due to preventable factors. Indeed, most of health problems during adolescence do not take place as the result of disease, but considered as the outcome of risky decisions by adolescents (Whalen, Grunbaum, Kinchen, McManus, Shanklin, & Kann, 2005). Personality Trait of impulsivity refers to a key concept for psychopathological situations and risky decisions especially among adolescents (d'Acremont & Van der Linden, 2005). Post-hoc, cross-sectional and longitudinal research have considered the relationship between dimensions of impulsivity and risky behaviors at various age groups especially adolescence, which the results indicate the relationship between impulsivity and increased risky behaviors (Romer, 2010; McGue, Iacono, & Kreuger, 2006; Ellingson, Fleming, Vergés, Bartholow, & Sher, 2014; Crawford, Pentz, Chou, Li, & Dwyer, 2003; Khurana, Khurana, Romer, Betancourt, Brodsky, Giannetta, & Hurt, 2012; Castellanos-Ryan, Rubia, & Conrod, 2011; Pieters, Burk, Van der Vorst, Wiers, & Engels, 2012). Impulsivity refers to a multidimensional concept (Wong, Nigg, Zucker, Puttler, Fitzgerald, & Jester, 2006). A problem which is discarded in the literature related to impulsivity and risky behaviors is a way of impulsivity for tendency to act without thinking which has been examined under poor behavioral control (Wong et al., 2006). Delay discounting is considered as another form of impulsivity, that is, delay discounting reduces as the result of delay in access to it over the time (Richards, Zhang, Mitchell, & de Wit, 1999). Evidences from animal and human models indicate that these two forms of impulsivity are independent from each other, i.e. the individuals who display a type of impulsivity do not express another type (Pattij & Vanderschuren, 2008; Reynolds, Penfold, & Patak, 2008). Thus, these two forms of impulsivity forecast some of risky behaviors (Khurana et al., 2012). Numerous studies have confirmed the bond

between weakness in executive functions and increased impulsivity and risky behaviors (Stanford, Greve, & Gerstle, 1997; Finn, Justus, Mazas, & Steinmetz, 1999; Villemarette-PittmanStanford, & Greve, 2003; Whitney, Jameson, & Hinson, 2004; Shamosh, DeYoung, Green, Reis, Johnson, & Conway, 2008; Romer, Betancourt, Brodsky, Giannetta, Yang, & Hurt, 2011). Executive functions are described as a series of cognitive skills related to purposive behavior which involve various abilities such as handling, update and retention (Miyake, Friedman, Emerson, Witzki, & Wager, 2000). Working memory capacity is considered as a central element which connects various but related executive functions to each other (Kane et al., 2002). Recent theoretical and empirical studies suggest that the correlation between impulsivity and risky behaviors might be moderated through working memory capacity (Ellingson et al., 2014). According to cognitive–motivational theory of Finn (2002), position of working memory capacity as a moderator elaborates the relationship between personality vulnerability and risky behavior. According to Cognitive-motivational theory of vulnerability, it is assumed that working memory capacity puts a main effects on decision making, served as a moderator of risky behaviors (Finn, 2002). According to Cognitive-motivational theory of vulnerability, working memory capacity as a short-term storage activation capacity, Capacity to resist distraction, Capacity to maintain the activation of items and Engage in Dual tasking (Finn, 2002). Some studies have provided supports for cognitive-motivational theory. In a study by Finn & Hall (2004), it has been indicated that working memory capacity independent of intelligence moderates effect of social deviance on alcohol problems. Further, findings indicated that group with low working memory capacity but high impulsivity has reported greater risk taking in the context of alcohol problems. Indeed, this group is more likely subjected to risk. Grenard, Ames, Wiers, Thush, Sussman& Stacy (2008) in another study concluded that associations to drugs in memory forecast drug use in a stronger way in students with lower levels of working memory capacity. Hofmann, Gschwendner, Friese, Wiers & Schmitt (2008) in their study found that impulsive processes determining behavior are more prevailed in the individuals who lack the required working memory capacity. Hence, this group acts poorer in self-regulation of Sexuality, eating behavior, and anger expression. Further, Ellingson et al. (2014) have conducted a research which examined interactive effect of working memory capacity and impulsivity on risky behavior. In this study, it has been displayed that some of indices of impulsivity are moderated in relationship with alcohol involvement by means of working memory capacity. Few studies have been conducted to test Cognitive-motivational theory of Finn (Finn & Hall, 2004; Ellingson et al., 2014). Further, extension of this theory in the context of a series of risky behaviors at adolescence regarding specific developmental conditions at this period has been discarded in the literature review. On the other hand, there are few investigations about moderator role of working memory regarding recent conceptualization (Friedman, 2012). According to study on literature review at this area, few studies have examined moderator role of working memory in relationship between impulsivity and alcohol involvement and perceived that working memory capacity moderates the relationship between impulsivity and alcohol involvement; further they have not found any moderator effect in use of working memory updating (Ecker, Lewandowsky, Oberauer, & Chee, 2012). Further, concurrent attention to role of executive functions regarding recent theories which have put emphasis on role of working memory capacity as a static process and updating working memory as a dynamic process in forecasting risky behaviors is another orientation in the present study (Ecker, Lewandowsky, Oberauer, & Chee, 2010).

2. Materials and Methods

2.1 Participants

Participants consist of 364 first and second grade high school students (mean: 15.1 and standard deviation: 1.43). Data were collected via self-reporting questionnaires and behavioral tests from ten schools in Damghan city.

2.2 Scales

2.2.1 Working Memory

N-bank test (Jaeggi, Buschkuehl, Jonidas, & Perrig, 2010): an task to measure cognitive functions relates to the executive functions. The general process lies on this fact that a sequence of stimulants is proposed step by step to the participant and the participant should examine whether the current proposed stimulant adapts with stimulant of step n before it or not. This test is made with various n values, so that task difficulty increases by increasing n value. Since this task includes holding cognitive information and manipulating them, it has been recognized to measure suitable working memory function (Chen, Mitra, & Schlaghecken, 2008). In the present study, computer version of n-back assignment is used which has been designed by Nejati. Result from this task includes sum of proper responses that some of improper responses and responseless items are subtracted from it by gaining a negative score (Nejati, 2013). Kane, Conway, Miura & Colflesh (2007) reported that validity of this test is acceptable as the index to measure working memory function. Validity coefficients ranging from 0.54 to 0.84

display high validity of this test.

Audio and visual span subtests of the Wechsler reverse numbers (Wechsler, 1981).

Nowadays, various subsets of Wechsler Intelligence Scale are used as the index to measure cognitive functions (Hill, 2008). Since this subtest includes cognitive processes such as attention, focus, subjective control, memorizing and information manipulation, it can be considered as the index for working memory function at the areas of executive system (Kaufman & Lichtenberger, 2006). In digit span subtest, a sequence of digits ranging from 1 to 9 with time interval about one digit per second is read for the participant, so that the participant should repeat the heard digits at the direct section and repeat the heard digits inversely at the inverse section. In visual section, the process is executed in this way with this difference that the digits are proposed visually (Kaufman et al., 2006). Performance in both direct and inverse ways is scored as the total series which have been memorized properly. Memorizing digits at inverse section is considered as an index of working memory capacity (Kaufman et al., 2006). Tests have high correlation with other central executive measures and have high validity (Wechsler, 1981).

2.2.2 Impulsivity

The Barrat Impulsivity Scale, 11 Version (BIS-11) (Barratt, Stanford, Kent, & Felthous, 2004).

The Barrat Impulsivity Scale, 11 Version (BIS-11) is a self-reporting scale consisting of 30 items which measures impulsivity. This scale includes three subscales of attention Impulsivity, motor Impulsivity and unplanned impulsivity (Barrat et al., 2004). The participant should give response to each of items of this questionnaire based on four-point Likert scale. 11 items among 30 items of this scale are scored inversely. Minimum and maximum score in the considered scale equals to 30 and 120 (Ekhtiari, Safaei, Esmaeili Javid, Ateb Vahid, Edalati, & Makri, 2008). Various studies have reported acceptable validity of this scale (Stanford. Mathias, Dougherty, Anderson, & Patton, 2007). Cronbach's alpha coefficient for the questionnaire in the group with drug abuse and healthy counterparts among Iranian population was reported 0.84 and 0.83 (Ekhtiari, Rezvan fard, & Makri, 2008).

Delay discounting scale (Richards, Zhang, Michelle, & Witt, 1999).

Measurement of delay discounting process is made in two methods. Standard method and another method are grounded on random logic. In standard method, value of a fixed reward is measured compared to descending digits after certain pauses. This comparison is made in form of two-item questions via software (Richards et al. 1999). In this study, Persian edition of this test which has been designed by Nejati and confirmed in efficiency among Iranian population was used. Information of standard version was registered in form of failure point for each of eight pauses for any person (Ekhtiari, Behzadi, Janati, & Moghimi, 2004).

2.3 Risky Decision Making and Behaviors

Barratts Impulsivity Scale (Lejuez, Aklin, Jones, Richards, Strong, Kahler, & Read, 2003: in this computer test, participants can save a certain amount of money in the temporary box on the screener by pushing the button on the keypad which causes inflating a balloon (Rezvan fard et al., 2007). This computer test examines the person's risk-taking under real conditions and measures function of his risky strategy (Nejati, Shiri, Dust Mohammadi, Barzegar, & Mohammadi fard, 2013). In this test, scores are taken into account as follow: 1-set scores: it represents the mean of number of pumping balloons which have not inflated. This variable is the main score of test and risk-taking index; 2-non-set score: it represents mean of number of pumping the balloons; 3- number of bursting balloon; 4- minimum and maximum number of inflating a balloon (Nejati et al., 2013).

Iranian Adolescents Risk-taking Scale (IARS) (Ahmad Abadi & Heidari, 2008):

This questionnaire was formulated by Zadeh Mohammadi et al. (2008) to measure risk-taking among Iranian adolescents. 30 questions are used to measure risky behaviors including driving, violence, smoking, drug abuse, alcohol abuse. Respondents have mentioned their agreement or disagreement with these questions in a five-point scale from totally disagree to totally agree. This questionnaire consists of 50 consistent items without inverse scoring, thus higher score indicates higher risk taking (Zadeh Mohammadi et al., 2008). Validity of this scale was examined via internal consistency and Cronbach's alpha and construct validity of this scale was examined via exploratory factor analysis and analysis method of main components. Value of Cronbach's alpha was obtained for the general scale equal to 0.94 and for the dimensions of questionnaire equal to 0.72 to 0.93. Obtained results indicate that validity of scale can be a suitable instrument in measuring risk taking among Iranian adolescents (Zadeh Mohammadi et al., 2008).

2.4 Data Analysis

In this study, data were analyzed in SPSS22. To examine moderator effect of working memory on the relationship between impulsivity and risky decision making and behaviors, two-factor variance analysis was used.

3. Findings

Descriptive findings of the present research include mean, standard deviation, skewness and kurtosis of participants' scores in the variables of auditory and visual working memory capacity, updating working memory, impulsivity, delay discounting, risky decision making in Table 1.

Table 1. Descriptive findings related to variables

Indices	Mean	SD
Variables		
Auditory working memory capacity	4.72	2.79
Visual working memory capacity	5.56	3.45
Updating working memory	20.02	5.92
Impulsivity	41.22	7.24
Delay discounting	10.44	19.07
Risky decision making	25.04	13.16
Risky behaviors	40.27	9.84

Table 2. Results from two-way variance analysis for the role of updating working memory in the relationship between impulsivity and delay discounting and risky behaviors

Dependent variable	sources	Sum of squares	Mean of squares	Df	F	P
Risky behaviors	Main effect of updating working memory	272.950	4689.119	1	3.261	.072
	Main effect of impulsivity	4689.119	272.950	1	56.027	.001
	interaction effect	535.999	535.999	1	6.404	.012
	Main effect of updating working memory	163.908	163.908	1	1.704	.193
	Effect of delay discounting	363.616	181.808	2	1.891	.152
	interaction effect	66.036	33.018	2	.343	.710

Table 3. results from two-way variance analysis for the role of auditory working memory in the relationship between impulsivity and delay discounting and risky decision making

Dependent variable	Source	Sum of squares	Mean of squares	Df	F	P
Risky decision making	Main effect of auditory working memory capacity	542.446	180.815	3	1.050	.370
	Main effect of impulsivity	174.520	87.260	2	.507	.603
	interaction effect	2241.719	373.620	6	2.170	.045
	Main effect of auditory working memory	1092.919	364.306	3	2.066	.104
	Effectof delay discounting	359.362	179.681	2	1.019	.362
	interaction effect	815.990	135.998	6	.771	.593

With regard to Table 2, main effect of impulsivity and interactive effect of impulsivity and updating working memory on risky behaviors are significant. But main effect of delay discounting, working memory, and interactive effect of updating working memory and delay discounting on risky behaviors are not significant. With regard to the data from this table, just impulsivity and impulsivity in interaction with updating working memory involve in risky behaviors.

With regard to Table 3, just interactive effect of impulsivity with auditory working memory capacity is significant in risky decision making. No main and interactive effects of delay discounting on risky decision making are significant. Data indicate that risky decision making is under influence under the conditions undergoing interaction between impulsivity and auditory working memory.

Table 4. Results from two-way variance analysis for the role of visual working memory in the relationship between impulsivity and delay discounting in risky decision making

Dependent variable	Source	Sum of squares	Mean of squares	Df	F	P
Risky behaviors	Main effect of visual working memory capacity	399.349	133.116	3	1.695	.168
	Main effect of impulsivity	6758.988	3379.494	2	43.023	.000
	interaction effect	991.350	165.225	6	2.103	.052
	Main effect of visual working memory capacity	615.483	205.161	3	2.153	.093
	Effect of delay discounting	435.222	217.611	2	2.284	.103
	interaction effect	544.082	90.680	6	.952	.458

With regard to Table 4, main effect of impulsivity and interaction of impulsivity with visual working memory capacity on risky decision making is significant. But main effect of working memory capacity and main effect of delay discounting in interaction with visual working memory capacity is not significant. Findings from this table indicate that just impulsivity and impulsivity in interaction with visual working memory capacity play role on risky decision making. Working memory capacity regulates the relationship between impulsivity and risky decision making.

4. Discussion and Conclusion

Main purpose of the present research is to examine Role of Working Memory updating and working memory capacity in moderating the relationship between impulsivity with Propensity of Risk Taking Behaviors and decision making in boy adolescents. In this study, moderator role of visual and auditory working memory capacity in relationship between some of dimensions of impulsivity and risky decision making was confirmed. The results indicate that visual and auditory working memory capacity has no direct role in risky decision making. But working memory capacity in interaction with impulsivity influences risky decision making. Under the conditions with low working memory capacity and high impulsivity, risky decision making increases, so that the level of decision making moderates by increasing amount of working memory. No effect of working memory capacity on risky decision making displays moderator role of working memory capacity on impulsivity (Amos, Tash, Sussman, & Stock, 2008; Tash, Amos, Sussman, & Stock, 2008; Ellingson et al., 2014). Finn & Hall (2004) reported in their research that social deviation (impulsivity) has stronger bond with the problems related to alcohol among the participants with low working memory capacity compared to the individuals with higher working memory capacity. Further, individuals with high social deviation and low short-term memory capacity than the individuals with high social deviation and high short-term memory capacity have reported higher scores in Michigan Alcoholism Screening Test (MAST). Grenard et al. (2008) in their study reported that associations related to drug among adolescents exposed to low working memory capacity compared to individuals with high working memory capacity are stronger forecasts for alcohol and cigarette abuse. Ellingson et al. (2004) obtained the same results with the findings of research by Finn & Hall (2004). According to recent study, it has been displayed that interaction between working memory capacity and social deviation forecasts alcohol involvement for three years. Results from this study are consistent with the related works (Finn & Hall, 2004; Ellingson et al., 2014; Finn, 2015), indicated that working memory capacity enables to moderate the relationship between some

of dimensions of impulsivity in relation to risky decision making. As mentioned by Ellingson et al. 2014, it is still unclear that why just the relationship between some of impulsivity dimensions and risky behaviors is moderated through working memory capacity. However such findings are consistent with the results from other researchers. Evidences from human and animal models indicate that these two forms of impulsivity are independent from each other, i.e. the individuals with one type of impulsivity do not express another type (Pattij & Vanderschuren, 2008; Reynolds, Penfold, & Patak, 2008). Thus these two forms of impulsivity predict independently some of risky behaviors. Investigations indicate that act without thinking associates to risky tendencies to sexual intercourse (Khurana et al., 2012). Yet reduced discounting delay paves the way for a large range of undesirable behaviors. This process can serve as a mediator in most of disorders (Bickel, Yi, Kowal, & Gatchalian, 2011). The considered sample consists of a group of typical students, seemed that tests of some forms of impulsivity such as discounting delay display sensitivity to clinical population than typical population. According to Finn's motivational-cognitive theory, it is assumed that working memory capacity has a main effects on decision making, served with moderator role in risky behaviors. Indeed, activation of working memory capacity enables the individuals to prefer less activated information to high activated information during decision making, i.e. the more high memory activation, the facilitated desirable decision making. Hence, individuals with high working memory capacity than individuals with low working memory capacity enjoy more skills to keep less and more activated information in their mind (Finn & Hall, 2004). On the other hand, individuals with higher impulsivity prefer immediate rewards to delayed rewards (Finn, 2002). Further, studies indicate that immediate reward is more prevailed, affecting more decision making (Bechara, Damasio, & Anderson, 1994). In this study, an attempt was made to examine moderator effect of other components of working memory on the relationship between impulsivity and risky decision making and behaviors. In this research, moderator role of updating working memory in the relationship between impulsivity and risky behaviors was confirmed. However, moderation role of updating working memory in relationship between impulsivity and risky decision making was not confirmed. Updating working memory did not display a main effects on risky behaviors, but this component in interaction with impulsivity affects risky behaviors. Findings of the present research are not consistent with findings of research by Ellingson et al. (2014). These researchers have not obtained any moderator effect for updating working memory in relationship between impulsivity and involvement in alcohol, said that working memory capacity rather than updating working memory moderate such relationship. Despite the research by Ellingson et al. (2014) who used several tasks to measure updating working memory, just one 1-back task was used in the present research. However, the results in the present research are consistent with the results from indices of the present research (spatial 2-back) concerning evaluation of updating working memory. According to the study by Ellingson et al. (2014). Moderator effect of spatial 2-back task was confirmed. But moderator effect was disappeared when the results from this test were combined with two other tests. From point of view of Friedman (2012), one of the challenges and problems of executive functions relate to Task-impurity which influence measurement error and Systematic non-EF variance. We face problem to measure variance of executive functions. They believed that use of latent variable approach has not resolved such problem. When several tasks are used, this causes reduced Systematic non-EF variance and more pure common variance from all the tasks to measure considered executive function. Hence, in the present research, it seems that we face increased Systematic non-EF variance, suggested to used latent variable approach in next studies. Hence, it can know the contradictory of findings between two studies arisen from various orientations in making updating working memory measurement. In the present research, our investigations indicated that adolescents face problem in understanding discounting delay, caused the participant to pay attention to end of test rather than what instruction has asked him. It is suggested to tester to accompany the participant from the beginning to end of test performance in next studies. It is suggested to use latent variable approach to measure research variables as suggested by Friedman so as to reduce systematic error and measurement error.

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