

# The Impact of Hydrochloride Heroin on Mental Flexibility, Abstract Reasoning, Impulsivity, and Attention

Zahra Alam Mehrjerdi<sup>1\*</sup>, Sara Bakhshi<sup>2</sup>, Siavash Jafari<sup>3</sup>, Afsaneh Moradi<sup>5</sup>, Hamed Ekhtiari<sup>1,4</sup>

1. Neurocognitive laboratory, Iranian National Center for Addiction Studies (INCAS), Tehran University of Medical Sciences, Tehran, Iran

2. Department of Psychology, Faculty of Psychology and Educational Sciences, Roudhen Azad University, Karaj, Iran

3. Department of Health Care and Epidemiology, Faculty of Medicine, University of British Columbia, Vancouver, BC, Canada

4. Translational Neuroscience Program, Iranian Institute for Cognitive Sciences Studies (ICSS), Tehran, Iran

5. Department of Psychology, Faculty of Psychology and Educational Sciences, University of Tehran, Tehran, Iran

## Article info:

Received: 17 January 2011

First Revision: 10 February 2011

Accepted: 22 February 2011

## Key Words:

Addiction,

Attention

Executive Functions,

Hydrochloride Heroin,

Impulsivity.

## ABSTRACT

**Introduction:** Drug addiction could lead to severe impairments in executive and neurocognitive functions but study on the impact of hydrochloride heroin on executive functions has remained in infancy in Iran. The aim of this study was to examine the relationship between addiction to hydrochloride heroin and executive functioning in several cognitive domains including mental flexibility, abstract reasoning, impulsivity, and attention.

**Methods:** A total of 60 cases of young male addicts aged 18 to 21 were recruited from outpatient addiction clinics in Karaj city and were matched with 60 non-drug using controls. A test battery including the Wisconsin Card Sorting Test (WCST), Porteus Maze Test (PMQS), Serial Seven Subtraction Test (SSST), and Color Trails Test (CTT) were administered respectively.

**Results:** The patient group showed more problems in impulse control compared with the control group, while mental flexibility, abstract reasoning and attention were not affected.

**Discussion:** The findings indicated that addiction to hydrochloride heroin had a negative effect on impulse control. This issue could reflect the role of impaired inhibitory control on drug-seeking behaviors and relapse. Special treatment programs must be tailored to control impulsivity among addicts to hydrochloride heroin during treatment.

## 1. Introduction

Research on the neurocognitive impacts of hydrochloride heroin addiction is sparse and studies do exist include poly substance abusers; thus, they are unable to distinguish neurocognitive impacts of hydrochloride heroin from those of other illicit substances. In addition,

there is a paucity of research on hydrochloride heroin addiction and its effects on human executive functions. Executive system is a cognitive system that controls and manages cognitive processes. This system is named as the executive function, supervisory attentional system, or cognitive control. This system is also used to describe a defined collection of brain processes that are responsible for planning, abstract thinking, rule acquisitioning,

### \* Corresponding Author:

Zahra Alam Mehrjerdi, MA.,

Neurocognitive laboratory of Iranian National Center for Addiction Studies (INCAS), Tehran University of Medical Sciences. Address: No.669, South Karegar Ave, Tehran, 1336616357, Iran, Tel/Fax +982155421177.

Email: a.mehrjerdi@gmail.com

inhibiting inappropriate actions, initiating appropriate actions and selecting relevant sensory information (Struss & Knight, 2002). Studies show that individuals with damage to prefrontal cortex show impaired judgment, severe problem in organization, planning and decision-making (Stuss & Benson, 1984), as well as behavioral disinhibition and impaired intellectual abilities (Luria, 2002). In a laboratory setting, such individuals show impairments on assessment tests such as fluency tasks (Milner, 2002), planning (Shallice, 1982) and set-shifting (Milner, 1963).

Weinstein and Shaffer (1993) suggested that drug addiction could lead to executive dysfunctions in sustaining attention, impaired abstract reasoning and some other executive domains. Al-Zahrani and Elsayed (2009) studied cognitive flexibility, attention and speed of mental processing in a group of drug addicts and found that addicted participants had slower performance on the executive function tests compared with the control group. Studies show that heroin addicts tend to perform worse than healthy individuals on various dimensions of primarily prefrontal functions including attention, learning, working memory and pattern recognition respectively (Fishbein et al., 2007).

Ahmad and colleagues (1989) reported that heroin addicts performed less successfully than normal controls on the tests related to intelligence, memory, attention, concentration, and perceptual-motor coordination. In a study on 155 Iranian opioid and methamphetamine addicts and 130 normal subjects, Hekmat and colleagues (2011) showed that addicted participants performed worse in cognitive flexibility, attention and speed of mental processing compared with healthy participants.

Pau and colleagues (2002) in their study on 55 participants showed the impact of heroin on frontal executive functioning. Their study findings indicated that heroin addiction had a significant negative impact on impulse control. Executive dysfunctions associated with drug addiction have important clinical and therapeutic implications. Such deficits show changes to the underlying cortical, sub-cortical and neuromodulatory mechanisms that are the bases of cognition, and interfere with treatment and rehabilitation of drug addicts (Rogers & Robbins, 2001; Ersche et al., 2006).

Although studies show that heroin abuse negatively impacts frontal executive functions but best to our knowledge, no study has investigated the impact of hydrochloride heroin on main frontal executive functions among young adult addicts in Iran. To address this aim,

the current study was designed to examine the impact of hydrochloride heroin on mental flexibility, abstract reasoning, impulsivity and attention in a sample of young adults in comparison with a group of healthy controls.

## 2. Methods

### 2.1. Subjects

Sixty male hydrochloride heroin addicts who met the Diagnostic and Statistical Manual of Mental Disorders-4th edition (DSM-IV) criteria for opioid addiction (American Psychiatric Association, 1994) and also met the inclusion criteria were recruited. This group was in abstinence from hydrochloride heroin use for 17(SD±4.4) days on average, and they were in methadone maintenance treatment program. Sixty healthy controls who reported no history of neurological, psychiatric or learning problems, no history or current drug use and no prior participation in the tasks related to executive functions were selected. Controls matched to cases on factors such as gender, age, education, and socioeconomic status. Participation was voluntary and informed consent was obtained at the onset of our study.

Inclusion criteria were 18-23 age range, the current route of smoking administration of hydrochloride heroin, normal vision, no history of physical and psychiatric conditions affecting cognitive and executive functions and no prior participation in the tasks related to executive functions. Exclusion criteria for the patient group included history of drug injection, poly drug use within the past 12 months except nicotine smoking and the presence of withdrawal and intoxication symptoms on the test day.

The Structured Clinical Interview for DSM-IV (SCID; First et al., 1995) was used to screen each participant for psychotic disorders, substance abuse and substance dependence. Informed and voluntary consent was obtained for each participant at the first visit. The protocol of the study was approved by the institutional review board of Roudhen Azad University in Karaj, Iran.

### 2.2. Tests

#### 2.2.1. Wisconsin Card Sorting Test (WCST)

Mental flexibility and abstract reasoning were measured by administering the Wisconsin Card Sorting Test (Heaton, 1981). The WCST was devised to measure abstract reasoning, mental flexibility, and set maintenance skills (Heaton et al., 1993). It consists of two 64-response card

decks and 4 stimulus cards. The WCST measures the executive cognitive functions of mental flexibility and complex problem-solving abilities amidst a set-shifting context. Perseverative error (repeated mistakes in matching the cards after being told of the incorrect response) and nonperseverative error scores (unrepeated mistakes; Heaton et al., 1993), were used as predictor variables.

A computerized version of WCST was administered and the number of completed categories, number of perseverative responses, percentage of perseverative errors, failure to maintain set score, and conceptual level response score were measured. Three scores (perseverative errors, number of trials, and number of categories) were completed and were recorded according to Heaton's administration procedure. Regarding the reliability, the study conducted by Axelrod and colleagues (1992) on 30 psychiatric adult inpatients who completed the WCST showed that the interscorer reliability was 0.92% and the intrascorer reliability was 0.94% for perseverative errors. Further studies on the WCST demonstrated that the number of categories achieved loads on both "complex intelligence" and "planning-organization" factors whereas the perseverative errors showed an important planning factor (Diagneault et al., 1988).

### 2.2.2. Porteus Maze Test (PMQS)

Impulsivity was measured by administering the Porteus Maze Test (PMQS) (Porteus, 1956). This test required the participants to trace a series of 10 mazes with increasing difficulty without going into blind alleys or crossing lines to avoid drawing around to reach an opening (Porteus, 1956). The study conducted by Gow and Ward (1982) on 90 students showed that those students who were rated as a below-average on the Teachers' Rating Scale of Impulsivity, received significantly higher scores on PMQS compared with other students. It provided an evidence of the concurrent validity of Porteus Maze Test.

### 2.2.3. The Serial Seven Subtraction Test (SSST)

The Serial Seven Subtraction Test (Smith, 1967) was administered to measure focused attention ability. Each participant was instructed to subtract 7 from 100 repeatedly. Both number of errors and time taken were recorded as the prominent indicators of the participants' focused attention. Shum and colleagues (1990) studied the construct validity of the SSST and reported that the test measured the ability to focus on mental processing and this construct was basically the same for the normal

participants and a group of patients diagnosed with head injury.

### 2.2.4. Color Trails Test (CTT)

The Color Trails Test (CTT; D'Elia, Satz, Uchiyama, & White, 1996) was administered to measure complex divided attention and sustained attention, abilities that are considered to reflect frontal lobe perceptual tracking function (i.e., ability to locate different elements within a predetermined time), sequencing (i.e., ability to achieve numeric order according to the required task), and motographic ability (i.e., ability to achieve fine motor coordination suitable to the task). The CTT is administered to individuals over 18 years of age and consists of using a pencil to connect, in ascending order, 25 numbers (CTT 1) and alternate colors (CTT 2) in "the shortest time possible".

This measure was found to be useful in several studies that obtained good correlational indices (Dolan et al., 2008; Lee & Cheung, 2005). A Brazilian study on the psychometric evaluation of the Color Trails Test (CTT) showed good accuracy ratings on the measures of the CTT, including time of execution form 1 (0.76%) and form 2 (0.82%) respectively (Sant' Ana Rabelo et al., 2010).

## 2.3. Study Procedure

The study procedure was conducted in strictly laboratory conditions in the laboratory of the department of psychology at Roudhen Azad University in Karaj city in Iran. Each participant was assessed individually. Demographic data and details of hydrochloride heroin use were completed for each participant by a questionnaire designed by the research team and then the tests were administered.

## 2.4. Statistical Analysis

Demographics and details of hydrochloride heroin use were analyzed by performing frequency, percentage, mean and standard deviation. The univariate analysis of covariance procedure (ANCOVA) was performed to measure the differences in the performances of the two groups on the study tests.

## 3. Results

Sixty male hydrochloride heroin addicts (mean age=20.3, SD=2.1; mean years of education=11.4, SD=7.6) and sixty healthy non-drug taking partici-

pants (mean age=20.2, SD=2.3; mean years of education=12.3, SD=6.6) participated in the study. Duration of addiction to hydrochloride heroin was 4 (SD=5.2) years. The main route of hydrochloride heroin administration was smoking within the past 12 months.

Descriptive statistics of the performances of the two groups of participants as well as the results of the ANCOVA are presented in Table 1. The results showed that

only the PMQS scores were significantly different between the two groups [ $F(1, 51) = 4.233, P = .046$ ]. As shown in Table 1, the participants who were addicted to hydrochloride heroin showed more impulsivity compared with the control group. The results of the two groups on mental flexibility, abstract reasoning and attention were not statistically significant indicating that cases did not differ from controls in other executive functions measured in this study.

**Table 1.** The results of the 2 groups on the study tests (n=120)

Measures	Patient group		Control group		F	P
	Mean	SD	Mean	SD		
Number of preservative errors (WCST)	18.73	13.61	12.91	8.18	0.003	0.933
Number of categories completed (WCST)	4.10	2.08	5.38	0.96	2.668	0.108
Number of trails (WCST)	108.76	23.29	99.18	20.10	0.000	0.985
Porteus Maze Qualitative Scores (PMQS)	34.33	23.81	17.34	13.43	4.233	.046*
Time spent (SSST)	53.62	20.33	62.21	42.18	0.523	0.467
Number of errors (SSST)	3.43	2.37	1.42	1.26	3.262	0.08
Time spent (CTT1)	31.32	7.15	26.76	6.71	2.083	0.169
Time spent (CTT2)	66.34	15.51	58.18	15.37	0.488	0.479

NEUR SCIENCE

#### 4. Discussion

The present study is one of the first studies that examined mental flexibility, abstract reasoning, impulsivity, and attention in a sample of young Iranian adults who were addicted to hydrochloride heroin smoking. We found that impulsivity was significantly higher in the patient group compared with the normal controls. This is consistent with the study findings of Weinstein and Shaffer (1993) showed that long-term drug use brings neuropsychological difficulties. Verdejo and colleagues (2005) showed that the cognitive function of heroin addicts was lower compared with ex-addicts. In a similar study on 30 heroin addicts and 25 normal controls, Pau and colleagues (2002) showed that heroin addiction had a negative impact on impulse control.

Ersche and colleagues (2005) also assessed affective impulsivity and found that increased risk-taking behavior was observed in a group of methadone-treated patients compared with a group of opiate addicts.

In our study, the mean PMQS score for the addicted participants was 34.33. This score is highly above the critical cut-off, indicating that chronic exposure to hy-

drochloride heroin of abuse is suggested to result in a condition associated with impulsivity that may contribute to compulsive drug-seeking and drug-taking behaviors.

Impulsivity is a personality trait characterized by one's desire for initiating behavior without adequate forethought as to the consequences of their actions, acting on the spur of the moment. Eysenck and Eysenck related impulsivity to risk-taking, lack of adequate planning, and making up an individual's mind quickly. It may also emphasize the roles of orbitofrontal cortex and right inferior frontal gyrus in impulse control (Berlin et al., 2004 & Salmond et al., 2005).

Drug abuse and addiction reflect behavioral states involving increased allocation of behavior towards drug seeking and taking at the expense of more appropriate behavioral patterns. As such, addiction can be viewed as increased control of behavior by the favorite drug. However, whether impulse control problem predisposes an individual to smoke hydrochloride heroin or impulsivity is a consequence of hydrochloride heroin addiction is a question which is an avenue for extensive longitudinal research studies.



Furthermore, given that impulse control is an important element in effective rehabilitation and treatment programs for hydrochloride heroin addicts, based on the findings of our study, a number of points may be considered in the planning of treatment programs for hydrochloride heroin addicts to improve impulse control.

The reversibility of the effect of hydrochloride heroin smoking on impulse control is still subject to research because impulsivity may hinder patients' ability to benefit from treatment programs for addiction. Strang and Gurling (1989) showed in their study that substance-specific effects of heroin on executive functions should be examined within the long-term use of high doses of heroin.

Our study results indicate that mental flexibility, abstract reasoning and attention were unaffected. It may be partly due to the young age of the sample, relatively a short duration of addiction to hydrochloride heroin smoking and low dose of use. Our study results also support the findings of a study conducted by Pau and colleagues (2002). They showed that heroin addiction had no effect on mental flexibility, abstract reasoning and attention in a sample of heroin addicted subjects compared with a sample of healthy non-drug taking subjects.

Based on the findings of the current study, we suggest that hydrochloride heroin, if smoked for relatively a short period of time, may not result in any significant impairments on the frontal executive functions measured, other than impulse control.

A better understanding of how addiction to hydrochloride heroin changes frontal executive functions may result in developing new treatment and rehabilitation approaches for executive dysfunctions of this group of drug addicts in Iran. It should be noted that our effort to evaluate the effects of hydrochloride heroin addiction on mental flexibility, abstract reasoning and attention need study with greater numbers of cases, with longer duration of exposure to hydrochloride heroin smoking and a history of poly substance use.

## References

- Ahmad, S., Ahmad, H., & Bindra, G. (1989). Cognitive impairment in chronic heroin addicts. *Journal of Personality Clinical Studies*, 5, 237-240.
- American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington: American Psychiatric Association.
- Al-Zahrani, M.A., & Elsayed, Y.A. (2009). The impacts of substance abuse and dependence on neuropsychological functions in a sample of patients from Saudi Arabia. *Behavioral and Brain Functions*, 5, 48.
- Axelrod, B.N., Goldman, B.S. & Woodard, J.L. (1992). Interrater reliability in scoring the Wisconsin card sorting test. *Journal of Clinical Neuropsychologist*, 6, 16-26.
- Berlin, H.A., Rolls, E.T., & Kischka, U. (2004). "Impulsivity, time perception, emotion and reinforcement sensitivity in patients with orbitofrontal cortex lesions". *Brain: a journal of neurology*, 127, 1108-1126.
- Diagneault, S., Braun, C., Gilbert, B.N., & Proulx, R. (1988). Canonical and factorial structures of a battery of "frontal" neuropsychological measures. *Journal of Clinical and Experimental Neuropsychology*, 10, 58.
- D'Elia, L.F., Satz, P., Uchiyama, C.L., & White, T. (1996). *Color Trails Test-professional manual*. Florida: Psychological Assessment Resources.
- Dolan, S.L., Bechara, A., & Nathan, P.E. (2008). Executive dysfunction as a risk marker for substance abuse: the role of impulsive personality traits. *Behavioral Sciences and the Law*, 26, 799-822.
- Ersche, K.D., Roiser, J.P., Clark, L., London, M., Robbins, T.W., & Sahakian, B.J. (2005). Punishment induces risky decision-making in methadone-maintained opiate users but not in heroin users or healthy volunteers. *Neuropsychopharmacology*, 30, 2115-2124.
- Ersche, K.D., Clark, L., London, M., Robbins, T.W., & Sahakian, B.J. (2006). Profile of executive and memory function associated with amphetamine and opiate dependence. *Neuropsychopharmacology*, 31, 1036-1047.
- Fishbein, D.H., Krupitsky, E., Flannery, B.A., Langevin, D.J., Bobashev, G., Verbitskaya, E., et al. (2007). Neurocognitive characterizations of Russian heroin addicts without a significant history of other drug use. *Drug and Alcohol Dependence*, 90, 25-38.
- First, M.B., Gibbon, M., Spitzer, R.L. & Williams, J.B.W. (1995). *Structured clinical interview for DSM-IV (SCID)*. New York State Psychiatric Institute, New York.
- Gow, L., & Ward, J. (1982). The Porteus Maze Test in the measurement of reflection/impulsivity. *Perceptual and Motor Skills*, 54, 1043-1052.
- Heaton, R. K. (1981). *Wisconsin card sorting test manual*. Odessa, FL: Psychological Assessment Resources.
- Heaton, R.K., Chelune, G.J., Talley, J.L., Kay, G.G., & Curtis, G. (1993). *Wisconsin Card Sorting Test manual: Revised and expanded*. Odessa FL: Psychological Assessment Resources.
- Hekmat, S., Alam Mehrjerdi, Z., Moradi, A., Ekhtiari, H., & Bakhshi, S. (2011). Cognitive flexibility, attention, and speed of mental processing in opioid and methamphetamine addicts in comparison with non-addicts. *Iranian Journal of Basic and Clinical Neuroscience [English]*, 2, 12-19.

- Lee, T.M.C., & Cheung, P.P.Y. (2005). The relationship between visual-perception and attention in Chinese with schizophrenia. *Schizophrenia Research*, 72, 185-193.
- Luria, A.R. (2002). Frontal lobe syndromes. In: Pinken, P.J., Bruyn, G.W. (eds) *Handbook of Clinical Neurology*, vol 2. Amsterdam: North Holland, 725-57.
- Milner, B. (1963). Effects of brain lesions on card-sorting. *Archive of Neurology*, 9, 90-100.
- Pau, C.W.H., Lee, T.M.C., & Chan, S-F. (2002). The impact of heroin on frontal executive functions. *Archives of Clinical Neuropsychology*, 17, 663-670.
- Porteus, S. (1956). *The Porteus Maze Test and intelligence*. Palo Alto, CA: Pacific Books.
- Rogers, R.D., & Robbins, T.W. (2001). Investigating the neurocognitive deficits associated with chronic drug misuse. *Current Opinion in Neurobiology*, 11, 250-257.
- Salmond, C.H., Menon, D.K., Chatfield, D.A., Pickard, J.D., & Sahakian, B.J. (2005). "Deficits in decision-making in head injury survivors". *Journal of neurotrauma*. 22, 613-622.
- Sant' Ana Rabelo, I., Verônica Pacanaro, S., Rossetti, M d O., Almeida de Sá Leme, I.F., Ribeiro de Castro, N., Marchi Güntert, C., et al. (2010). Color Trials Test: a Brazilian normative sample. *Journal of Psychology and Neuroscience*, 1, 93-99.
- Shallice, T. (1982). Specific impairments of planning. *Philosophical Transaction of the Royal Society of London B*, 298, 199-209.
- Shum, D.H.K., McFarland, K.A. & Bain, J.D. (1990). Construct validity of eight tests of attention: Comparison of normal and closed head injured samples. *Clinical Neuropsychologist*, 4, 151-162.
- Smith, A. (1967). The serial sevens subtraction test. *Archives of Neurology*, 17, 78-80.
- Strang, J., & Gurling, H. (1989). Computerized tomography and neuropsychological assessment in long-term high-dose heroin addicts. *British Journal of Addiction*, 84, 1011-1019.
- Stuss, D., & Knight, R.T. (Editors). (2002). *The Frontal Lobes*. New York: Oxford University Press.
- Stuss, D.T., & Benson, D.F. (1984). Neuropsychological studies of the frontal lobes. *Psychology Bulletin*, 95, 3-28.
- Verdejo, A., Toribio, I., Orozco, C., Puente, K.L., & Perez-Garcia, M. (2005). Neuropsychological functioning in methadone maintenance patients versus abstinent heroin abusers. *Drug and Alcohol Dependence*, 78, 283-288.
- Weinstein, C.S. & Shaffer, H.J. (1993). Neurocognitive aspects of substance abuse treatment: A psychotherapist's primer. *Psychotherapy*, 30, 317-333.