Psychology in Russia: State of the Art
Volume 7, Issue 2, 2014

Russian Psychological Society
Lomonosov Moscow State University

PSYCHOPHYSIOLOGY

Human errors: Their psychophysical bases and the Proprioceptive Diagnosis of Temperament and Character (DP-TC) as a tool for measuring

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Human error is commonly differentiated into three different types. These are: errors in perception, errors in decision and errors in sensation. This analysis is based on classical psychophysics (Fechner, 1860) and describes the errors of detection and perception. Decision-making errors are evaluated in terms of the theory of signal detection (McNicholson, 1974), and errors of sensation or sensitivity are evaluated in terms of proprioceptive information (van Beers, 2001).

Each of these stages developed its own method of evaluation that has influenced the development of ergonomics in the event of errors in perception and the verbal assessment of personality (stress, impulsiveness, burnout, etc.) in decision-making errors. Here we represent the method we have developed, the Proprioceptive Diagnosis of Temperament and Character (DP- TC) test, for the specific assessment of errors of perception or expressivity which are based on fine motor precision performance.

Each of the described errors types are interdependent of each other in such a manner that observable stress in behaviour may be caused due to: the inadequate performance of a task due to the perception of the person (i.e. from right to left for a right-handed person); performing a task that requires attentive decision-making to be performed too hastily; undertaking a task that does not correspond to the prevailing disposition of the person.

Keywords: human error detection, Proprioceptive Diagnostic of Temperament and Character (DP-TC), diagnosis, prevention, expressivity, perception

Introduction

The aim of this article is to show the nature of error in human perception from a review of the theoretical work on this topic and of the experimental work and method created in the Laboratory of Mira y López (University of Barcelona) in

ISSN 2074-6857 (Print) / ISSN 2307-2202 (Online)

doi: 10.11621/pir.2014.0205
http://psychologyinrussia.com

order to understand its unintentional or unconscious mechanisms. The trends of specific and individual patterns in perception bias can be measured and assessed in comparison with the average values in populations using Proprioceptive Diagnostics of Temperament and Character, which can be considered an objective tool due to the difficulty of faking the performance (and results). It was developed by Tous (DP-TC, 2008) in the tradition of Mira y López (MKP, 1958) and describes specific trends in shifts from the graphical models that reflect specific characteristics of human dispositional behaviour (Miroshnikov, 1963; Tous J.M., Muiños, Tous, O. & Tous, J., 2012).

Theoretical basis of human errors

Background in security and the prevention of risks

The first reference to human error we can find is in Plateau (1872). When people registered changes in the observation of stellar phenomena, it was found that their observations reflected an error that was intended to be treated by an attempt to create a so called personal equation, which was dubbed the *error law* by Galton (1869). For Galton, the error was associated with personality traits, in such a manner that the dimensions of one's personality manifested in the degree to which there was a probability of committing an error of one or another type. Thus, from its onset, we note the existence of two different explanations for human error. On one hand, there is a personal equation for errors in observation and on the other hand there is a law of error in its appreciation. The importance of proprioception, both in introspection regarding individual life experiences and in perception was also mentioned by Vygotsky (1991):

> Only I can observe and collect my secondary reactions, because only for me my reflexes serve again as new excitatory stimuli in the proprioceptive field. The movement of my arm, perceptible by the eye, can be equally an excitatory stimulus, both for my eyes and to stranger's; however the awareness of this movement, the proprioceptive excitations that arise and cause secondary reactions there are just available for me. They have nothing in common with the first excitation of the eye. Here other nerve pathways act, other mechanisms, other completely different excitatory stimuli.

Sherrington, in his studies of animal reflexes, established the competitor principle in the motor field as a basic constituent of one's personality (Vygotsky, 1991). Pavlov (1941) and Sechenov (2013, originally published in 1863) also contributed to this field of knowledge. Mira y López, working with the "detector of lies" that had been created by Luria (1932) noticed that the amplitude of movement was different and did not depend on the context of the questions being asked and reflected the degree to which a person was more excitable or inhibited. In 1940, he presented his myokinetic psychodiagnosis (M.K.P.) at the Royal Medical Academy in London (Mira, 1958) in which he included his observations and the results of related experimental work.

Psychophysical exploration of human error

The objective of classical psychophysics was to describe the relationship between stimulation and perception (Kling & Riggs, 1971). Fechner's law (1860) states that the intensity of sensation (perception) is proportional to the logarithm of the intensity of stimulation, therefore the stimuli that are more relevant in intensity, quality, rarity, etc. will be best received by individuals and produce fewer errors. In these investigations, response was considered an "automatic reflex" due to the consideration that physical phenomena were only capable of producing mental responses via the sensory system.

By the law of absolute thresholds, Newton (1675) carried out the determination of the visible spectrum. Bouguer (1760) established the differential threshold for capturing luminosity variations. Delezenne (1827) proposed the differential threshold for variations of sounds. Weber (1846) used the concept of differential threshold, based on the concept of Just Noticeable Differences in the stimuli, and established touch-related variations. By comparing different sensory organs, the appreciation by touch was found to be superior to that achieved by vision.

In all these studies, the interest was in detecting the sensory thresholds that would allow someone to determine the discernment of a change in the physical magnitude of stimulation or the minimum variation of a stimulus that would allow the observer to detect it. This led to the distinction of absolute thresholds: the minimum or maximum magnitude of the stimulus to detect it and a differential threshold, the required amount of energy change of a stimulus in order that the observer could detect its change. The study of the differential threshold led to Weber's Law (1834), which states that detection does not depend on the absolute difference of the magnitude of stimulation, but on the relative difference in the magnitude of it.

Fechner (1860) proposed the so-called psychophysical parallelism, according to which, in order to establish a relationship between the physical magnitudes of stimuli and sensory magnitudes of detection, both of them should be considered separately. He distinguished between external and internal psychophysics, believing that the first would show the engines of physiological changes in response to changes in stimulatory energy, while the second shows the relationship between what is perceived by the senses (physiological engines) and sensations or expressiveness.

External psychophysics Internal psychophysics

Physical stimulus_____Sensory change_____Perception

Therefore, to Fechner, not only was the direct quantification of the stimuli possible, but that it is also possible to directly quantify bodily sensitivity. The units of sensations proposed by Weber as just-noticeable differences would correspond to the quantification of sensations or bodily sensitivity.

Contribution of the theory of signal detection

The theory of signal detection had a double beginning due to the collaboration between a group of engineers and a group of psychologists. Peterson, Birdsall and Fox (1954) represented the engineers and Tanner and Swets (1954) represented the psychologists. The theory of signal detection was developed in the 1960s and 1970s

(Green & Swets, 1966; McNicholson, 1972). This theory provides a solution to the problem posed by classical psychophysics regarding how to control and specify the criteria that the observer uses for a perceptual judgment.

Detection or perception Decision-making

Physical stimulus_____Sensory change_____Judgement

The occurrence of these errors is affected by task-related conditions, the difficulty discerning between two or more stimuli and personal decision-making styles. Errors that are due to task-related conditions are related to detection and perception, whereas errors that are caused by decision making are also related to personality.

By integrating the model of Fechner's psychophysical parallelism to model signal detection, we obtain the following:

Detection Perception Decision

Physical stimulus_____Sensorial change_____Perception_____Judgement

Peripheral process detection consists of the relationship between stimulus energy and a change in energy in the peripheral organ muscle, corresponding to stimulation that was described by Fechner with respect to external psychophysics. However, perception is an internal process which consists of the relation of the sensory organs to the cortex. Through this, muscle energy is transformed into nervous energy, which is attributable to the personal sensitivity which is the basis of Fechner's inner psychophysics. The decision-making process is understood as an interaction between different components which are presented in the cortex, i.e. the relationship between perception, attention, working memory, long term memory, etc. — the *decision* and the subsequent selection of previous response before execution (Massaro, 1975).

From this brief review of the main principles of classical psychophysics (Tous, 2011) and the theory of signal detection (Arnau, 1982) it can be seen that human error can be attributed to errors in detection, to errors in personal sensitivity and errors in decision-making. Two of these concepts were used by Green and Swets (1966) to develop the theory of signal detection. The intention of the theory was to differentiate between perception and decision making.

In all psychophysical methods, a great deal of previous training is required in order that the observer may avoid errors of anticipation, i.e. responding when the stimulus is not present or alternately, failing to respond when the stimulus was present. The theory of signal detection found a way of discerning and evaluating this type of error by determining when a person is likely to increase his/her sensitivity and make more mistakes due to false alarms when the stimulus is not present. These authors believe that an increase in the occurrence of this kind of error is not really due to increased sensitivity, but to an increase in the amount of criterion used in decision-making. This observation should be taken into consideration more frequently during safety training programs.

A false positive occurs when a "yes" answer is given when the correct answer is "no" and a false negative occurs when a "no" answer is given when the correct answer is "yes". When the difference between the stimuli to be compared is very large,

all "yes" answers are correct and when the differences are very small or absent, all "no" answers are correct. The problem appears in the intermediate values, in which it is more difficult to discern between the two stimuli. In these cases, decision-making related criteria take an important role; they become more important than sensitivity.

If the decision-making criterion used is conservative, very few false positives will arise, but few guesses will be right, because the answer will only be correct when you are sure of the difference, i.e. when a "yes" response is given when there is a real difference. However, if the criterion is liberal, many false positives would arise, because it would be easy to consider a difference to be present; however, the number of right guesses will increase (Tous, 2012).

Limitations on risk assessment

In certain real-life activities, it is believed that it's better for false positives to arise since they allow for a greater number of right guesses; however, it is correct is to make few false positives. The proposed examples can be interpreted differently, depending on whether people are more stylistically conservative or liberal. When pardoning a prisoner, the authorities may use either conservative or liberal criteria when they are not completely sure of his/her rehabilitation. When permitting the landing of an aircraft, one may use either conservative or liberal criteria when weather conditions do not allow one to be absolutely sure of the success of the operation; nowadays there are sophisticated landing systems to provide a high probability of safety in such cases, but it is still a good example because airports still exist which lack such systems. However, what we are interested in is the differential effect of taking one or another kind of decision in each given example. In the case of convicted offenders, if we use the liberal approach, we ensure that every prisoner which deserves to be paroled is set free, but some are freed who do not deserve it. In the case of landing, using of the liberal criterion ensures that all aircrafts which are able to land successfully can obtain authorization, including some aircraft that need to manoeuver more due to the weather. The question is whether the consequences of this liberal decision are the same in one example or another. Obviously people with a conservative approach would consider both liberal approaches equally damaging. However, it is possible to see that in the first case it may be better, for society's sake, to use a conservative approach in order to ensure that dangerous criminals aren't liberated; whereas in the second case it would alarm the passengers less if liberal criteria were used, in order to ensure that all aircraft that are already making the approach can land and that planes which have not yet started to approach the runway can start to do so. This kind of knowledge should be available to all those whose decisions affect the lives or living conditions of others, such as politicians, economists, and pilots among others, since otherwise everything would depend on just their personality: conservative or liberal.

Although the theory of signal detection discusses the relationship between sensitivity and decision-making criteria, in fact they refer to the relationship between detection or perception and decision making. The theory of signal detection denominates sensitivity in terms of what Fechner considered as external psychophysics, namely, the relationship between physical stimuli and changes produced in interac-

tion therewith, in the sensory organs. However, as we have seen already, Fechner's internal psychophysics deals with the relationship between changes produced in the sensory organ and the subsequent confirmation of this in the spinal reflex or cortical bioelectric change. In practice, it is the passage of biophysiological muscle energy in nervous energy that is capable of generating a nerve response which in its turn modifies our muscles to execute the appropriate response. It is possible that the lack of availability of this myokinetic information in the evaluation system has prompted the neglect of the investigation of sensitivity, one of the components that were proposed by Fechner. We conceptualize it as an expressive component that is not studied in behaviour and that undoubtedly also contributes to the realization of errors like the adaptive component. The difference between these components is that the component is easily modified by adaptive learning, since this is a culturally-acquired component, while the expressive component should be considered in another way, since it is not susceptible to change in the same way. It is obvious that people in common situations, having learned and gained more experience, would manifest a larger percentage of their adaptive behaviour when compared to their expressive behaviour; nevertheless, human behaviour is impossible without the expressive component. In contrast, people in unforeseen circumstances, which are new to them, or where they simply haven't had sufficient experience or training, would manifest a higher percentage of expressive conduct of adaptive behaviour.

Contributions

Ergonomics and human risk assessment factors are of the highest help when improving the adaptive component of behaviour, however these hardly affect its expressive component. In a study conducted in the company Empetrol (Tarragona), it was empirically shown that the detection of high-risk factors and generalized rules to achieve greater security had been very useful there; however other factors appeared there, such as lower security for these persons (Tous, 2012).

Proprioceptive Diagnostics of Temperament and Character (DP –TC) as a graphical test based on fine motor precision

Brief description of DP-TC

A Proprioceptive Diagnostic of Temperament and Character (DP -TC) (Tous et al., 2012; Liutsko & Tous-Ral, 2012) is an objective psychological tool where higher limb movements are recorded directly; they performed when the subject is not able to see his/her active hand. This facilitates the indirect assessment of six functional dimensions of one's personality: 1) Mood: Pessimism — Optimism (depression vs. mania); 2) Decision-making: Submission — Dominance (auto- vs. hetero- aggression); 3) Attention Style: Intra- and Extra- attention (open vs. closed); 4) Emotionality: Distant — Affectionate (cold vs. warm); 5) Irritability: Inhibition — Excitability (inhibition vs. irritation), and 6) Impulsivity /Variability: Rigidity/Stiffness — Variability (immutable vs. mutable)

These six dimensions are designed to assess and predict six different dispositions of normal and abnormal behaviour, which are present in every person as properties that are manifested as temperament when executed with the non-dominant hand

(for the majority, it is the left hand and the right hemisphere of the brain) and as character when they are performed with the dominant hand (for the majority, it is the right hand and left hemisphere). The dimensions assessed from the dominant hand's performance are considered to be personal characteristics a as result of the interaction between dispositions in temperament and the concrete environment in which they have been developed (Tous et al., 2012).

Instrument

Nowadays it is widely accepted that temperament and personality may be directly assessed based on verbal evaluation (a personality assessment test). The assessment that we propose refers to a different concept of personality which consists of one or more sets of behaviours. The personality and its elements are behavioural strategies that constitute individual properties or characteristics that are genetically transmitted. The novelty of this system consists in that it assesses indirectly (through movement expressed by the hand in graphical response) the influence of proprioceptive information via posture, the expression of emotions and behaviour. Systematic biases in the direction of the movement in motor behaviour start in in the different types of proprioceptive information which exist in each spatial plane. These compose different forms of being (personality) that are observable in every person (in their performances, emotions and cognitions) (Tous, Muiños, Liutsko & Forrero, 2012; Liutsko, 2013).

The DP- TC is formed by two kinds of linear graphical models or stimuli: a) lines (or lineograms) and b) parallels. The participant should trace each line of the presented model precisely and draw parallels that are of equal length and equidistant from one another. There are six line models that represent a line for two hands (dominant and non-dominant) and three movement types (frontal, transversal and sagittal). The parallels are traced and drawn by both hands in ascending and descending order. All tasks are performed while the active hand is in sight and graphical feedback then and afterwards continues; without it we would depend on the effect of proprioceptive information on movement.

Figure 1. The DP-TC test performance (photo by Liutsko, L.)

To administer the DP -TC and interpret it properly, it is recommended that one be familiar with the theory and significance of the functional personality dimensions proposed by this methodology (Tous, Viadé, Chico, & Muiños, 2002; Tous & Viadé, 2002; Tous, Viadé, & Muiños, 2007; Tous et al, 2012; Liutsko & Tous, 2013; Liutsko, 2013a,b). One must also be aware of possible age, sex and cultural differ-

ences that could affect the results (Liutsko & Tous, 2014; Liutsko, Muiños & Tous, 2014; Liutsko, 2013b).

The technician (who applies this test) has to think about a person's body position throughout the test, as well as the way the participant holds the pen and uses it. Those responsible for the testing should also cautiously screen the active hand when the proprioceptive part of the test starts (without vision) in such a manner that it doesn't interfere with correct performance. Moreover he/she should ensure that all instructions are well- understood and followed during the test. It is desirable that the test administrator had his/her own prior training to rely on — who has attended the accreditation course that is part of the skilled training in this psychological evaluation system, which is provided with the test implementation software. The tests should be conducted individually. The computerised and automatic correction of the test is quantitative; however, the expert can make his/her own observations of qualitative individual performance during the testing.

The evaluation is based on the registering of errors, in millimetres, that help to empirically determine precision according to: a) movement direction and b) shape of movement. Displacements from linear models, or errors, are empirical indicators of the trends in each movement.

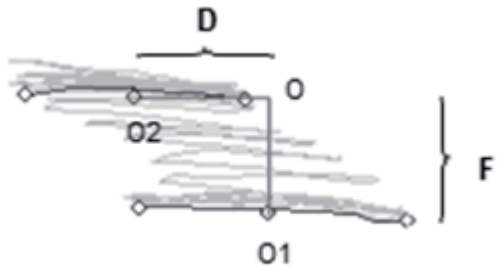

Figure 2. Systematic graphical errors in proprioceptive lineogram performance (without visual guidance): D — directional error (parallel to the model line); F — formal error (perpendicular to the model line)

Method

The sample consisted of N = 745 participants from the general population aged between 14 and 68 years with a mean age of 22.0 years and a standard deviation of 5.8; 8.75 % were left-handed; men (N = 305; age range: 14÷68, mean age: 23.4±7.3 years; 10.5% left-handed) were slightly more likely to be left-handed than women (N = 440; range age: 15÷60; mean age: 20.6±4.1 years; 7.0% left-handed). No sensory/locomotive deficit or lack understanding the task instructions was present in the participants included in the study.

A Kolmogorov — Smirnov test for the entire sample showed that the dimensions of Emotionality and Variability/Impulsivity were significantly different from the normal distribution. Temporal stability was assessed by test-retest within a period of 30 Days (Table 1):

Table 1. Test-retest stability

Dimension		Correlation	*p*-value
Mood	T	.62	<.001
	C	.67	<.001
Decision-making	T	.40	.034
	C	.53	<.001
Style of Attention	T	.58	.003
	C	.57	<.001
Emotionality	T	.41	.031
	C	.42	.005
Irritability	T	.52	.003
	C	.47	.001
Variability /Impulsivity	T	.50	.003
	C	.49	.001

Legend: T — temperament and C — character

Although these parameters of the test's reliability are not very high, they were significant for all observable variables. The magnitude of correlation does not diminish the instrument, but reflect that on the one hand, human fine motor behaviour (as a form of general behaviour) is a dynamic system and not something fixed or rigid, whereas the DP-TC test is sensible to these changes. As per Raven's words (cited in Silva, 1989), *The correlation coefficient test-retest is a grade in which the psychologist expects the same results when the test is repeated; however, if with time, some changes occurs in the measured activity, a very high correlation would mean that this test was insensitive to these changes*.

Dimensions of the DP-TC test

The DP-TC test has six dichotomous pairs of dimensions which are obtained from biases in graphical movements from the initial model, when they are realized in the proprioceptive condition (without seeing an active arm/hand and tracing /drawing feedback). These dimensions are the following:

Mood: The participant's tendency to move up or down in the frontal plane, depending on greater or lesser intensity, would indicate an optimistic or pessimistic state of mood, vulnerability to anxiety, stress, or a depressive or manic state of the person. Directional movement up: (+) Prevalence of extensor shoulder muscles; the participant can compensate the action for gravity. If the tendency of movement is down: (-) Prevalence of flexor shoulder muscles; the participant cannot compensate the action for gravity.

Decision-making: Sagittal movement in the transversal plane, with a tendency of bias out from the body of the participant would show us a high readiness for decision making, assertiveness, a trend towards dominance, authoritarianism and vulnerability to feelings of aggression towards others. The tendency in sagittal

movement towards the participant's body is interpreted as a disposition towards indecision, submission, dependence and vulnerability to aggressiveness towards his/herself.

Style of attention: Horizontal movement in the transversal plane with a tendency to shift outward would indicate inattention (in higher magnitude), due to being involved in too many different things at the same time, openness to external stimulation and a disposition towards extroversion. The tendency to shift inward in this movement type would denote a lack of attention, an orientation towards one's internal content, to be closed off to external stimulation by putting all of one's attention on the inner world and introverted disposition.

Emotionality: Empirical observation has shown that there are people who, regardless of their precision, make more mistakes by moving from the shape of the model (formal errors that reflect the bias perpendicular to the model). Therefore changes from the shape of the model should be kept as another variable which is different from the directional errors (biases that occur parallel to the line model). They represent formal errors (biases that occurs perpendicular to the line model). Evaluating errors in the formal component of motion, either toward one side of the model or another, will reveal the personality disposition regarding emotionality.

Irritability: The assessment of this dimension is based on line length measuring compared to the model's length (40 mm). The tendency to increase or decrease the motor response to a graphical stimulus will provide information about one's tendency for excitability or inhibition (poles of Irritability).

Variability (Impulsivity): Assessing variability in line length performance (obtained from the parallels) will demonstrate variability or rigidity; these constitute the poles of this dimension.

Main applications of the DP-TC test

The test can be applied to teenagers and adults of both sexes (although it is not limited and can be used in children starting from 5-6 years old) in the general population. It tests peoples' ability to carry out regular or sporadic tasks of personal responsibility, make decisions in difficult times, pay attention to relevant and important aspects of each situation and determine their emotional balance. Also this test permits the evaluator to overcome cultural or educational problems, especially language, detect mental disorders and conditions (especially depression), and provide a quantitative assessment to clinically diagnose motor symptoms.

Different studies were conducted at the Laboratory of Mira y Lopez (University of Barcelona) to develop the methodology: from the scanned (PMK-R, Tous & Viadé, 2002) and digitalised (PMK-RD) versions with its standardization (Tous, Viadé, Pont, & Muiños, 2005) and structural validation (Tous, Viadé, & Muiños, 2007) to DP-TC (Tous et al., 2012) in which a touch screen was implemented for gathering of data. Also, experimental studies which use new technologies were performed to replicate Mira y Lopez ones, for example, the study of violence (Tous, Viadé, Chico, & Muiños, 2002) and other studies related to antibody levels and motor control (Tous, Vidal, Viadé, & Muiños, 2002), motor precision in elite sharpshooters compared to students (Tous, Viadé, & Muiños, 2002), prisoners and policemen

(Tous, Muiños, Chico, Pont, & Viadé), people with personality disorders (Tous, Grau, Viadé, & Muiños, 2005) and the relationship between verbal self-assessment and proprioceptive indicators in people who apply for gun licenses (Tous, Muños, & Liutsko, 2014, *in press*).

Similarly to MKP (Mira y López), the DP-TC can also be used to observe the somatic reaction of mental work (Mira, 1923; Liutsko, Tous, & Muiños, 2012); motor performance in stress adaptation (Ezhov & Krivoshchekov, 2004); psychophysiological markers of tolerance (Draganova, 2007); human behaviour in indigenous populations (Berezin, Varric, & Gorelova, 1976); in the detection of physical and mental health (Efremov, Sluchaevskii, Popov, Rozenfeld, &Dunaevskaia, 1982; Gironell, Luitsko, Muiños, & Tous, 2012; Liutsko, & Tous, 2013), and in sex, age and cultural differences (Liutsko & Tous, 2013; Liutsko, Muiños, & Tous, 2014). Moreover, the DP-TC test can be used to determine if pre-school children are ready for school as well as problems with TDAH (Iglesias, Luitsko, & Tous, *2014* (*in review)*; Liutsko, Iglesias, & Tous, 2014). The information, obtained by the graphical performance in the proprioceptive sensory condition, will help to realize therapy, coaching or re-education in a more effective way (Miroshnikov, 1963; Liutsko & Tous, 2013; Malova & Liutsko, 2013; Liutsko, Tous, & Gutiérrez, 2014).

In practice, the DP-TC test is used nowadays as an acceptable neuropsychological revision which is administered to those obtaining gun licenses or driving licenses; in diagnostics (psychological consultation and coaching), personnel selection (especially for professions related to risk or responsibilities over the lives of others) and individual or sport coaching.

Discussion

In the evaluation of the human factor in security, the way to avoid errors related to the expressive component of behaviour has traditionally been made through personnel selection, although sometimes it was done intuitively: it is believed that there are persons who are less adequate than others for certain tasks, especially related to risk. There are two limitations to this type of action. The first is that the specific professional activity feature may not be the optimal social value. The seconds reflects the fact that the way they evaluate these characteristics in people has little to do with their real behaviour, since it is usually obtained from their opinions of themselves and doesn't reflect what they actually do, or their behaviour.

Human behaviour depends on two different types of information which are different in nature. One's intention is a result of his/her mental content and thus acquired by his/her inculturation. The intention is made manifest in the adaptive component; and therefore there are situations in which it is easier to do what one intends and situations where it is more difficult. The easier situations are those that have served for learning and gaining experience, but even there, in order to carry out our intentions, we need other information if we are to be capable of converting intentions into execution. The other type of information, disposition, is present in the information we obtain internally from our bodily state. Every execution needs the contribution of muscle energy in order to realize it. When a person is planning the implementation of his intention, he doesn't only need the content of the intention, but also adequate muscle power at his disposition to carry it in one or another

form, for example, in a conservative or liberal way, as we have seen before (Tous, 2012).

Rantanen and Rosenbaum (2003), while working on their study on motor control, observed drifts in blind reciprocal aiming movements and they could not explained them then the nature of this drift. However, the results of their observation were clear: the drifts represented a systematic error in performance and this issue was crucial since aviators (with whom they also worked) could make such spatial errors. Mira y Lopez in 1939 worked with pilots and then observed that some of them could change their trajectory of movement (in flight) if visibility had been limited (dense fog) and for this reason he created his axioestereometer (Muiños, 2008) and later M.K.P. (Mira, 1958). From the personal correspondence with Dr. Rantanen and Dr. Rosenbaum, we found out they did not know then anything about the MKP of Mira y Lopez and the role of the human factor or personal and individual differences in perception, due to the scarcity of work available in English on it. Our study on changes in sensorial perception depending on hand use and movement type (frontal, transversal and sagittal) was one of the first works published on Perceptual Motors to start the dissemination of work in this direction (Tous-Ral, Muiños, Liutsko, & Forero, 2012). In Russia, we were put in contact with Prof. Berezin, who not only made use of the Mira y Lopez MKP when conducting research, but is an expert in personality and clinical psychology (Berezin, 2011). Moreover, we found more work that had been completed usingthe traditional Mira y Lopez method (Miroshnikov 1963; Efremov, Sluchaevskii, Popov, Rozenfeld, & Dunaevskaia, 1982; Ezhov & Krivoshchekov, 2004; Draganova, 2007).

The DP-TC (Tous et al., 2012) is an objective method since observable variables are taken from the part performed in the proprioceptive sensory condition (without visual guidance). The information about dispositional human behaviour can contribute in describing the personality, individual differences and behaviour in more complex ways (Tous et al., 2012; Liutsko, 2013) and this can also help to distinguish between what we pretend to be able to do and what we can do. It is important to know, especially in case of recruitment of persons for job position where the lives of others may be at stake (pilots or school bus drivers) or who are applying for a gun permit– until now, questionnaires have been used to detect violent or pathological behaviour and these results could be faked by those who mimicked social desirable behaviour when completing the self-report and some points cannot be confirmed by the proprioceptive test (Tous, et al, 2014, *in press*). Nevertheless, more studies should be conducted to find the relationship of our proprioceptive state based on fine motor performance to emotional control or other specific states of behaviour or illness. The method itself also deserves future improvement in order to be applied practically in other ways.

Conclusion

Changes in fine motor behaviour, which can only be registered using proprioceptive information, can be considered part of a form of empirical evaluation of conceptual axes that have been established for organizing personality traits, as suggested by Eysenck (1967). The mutable personality would manifest a great reactivity to environmental changes, whereas the immutable one would react very

little. The sensitive personality would manifest greater variability in emotionality to environmental changes, whereas the insensitive one would demonstrate little variability there.

Thus introversion — extraversion would be based on the motion that corresponds to the action to get and transform things. The stability — emotional instability axiom is based on the movement that manifests little or great sensitivity and generates a response of neuroticism. It would be the basis of a protection movement; this would correspond to one's predilection to avoid damage or danger to one's self. This all means a strategy based on avoidance coping for protecting us. This description of some personality models, which have been developed from the time of Wundt until the present, allows us to consider movement generated by our own or an endogenous body that we perceive through proprioceptive organs, which appears to be a good empirical indicator of trends toward action or toward protection that delimit the individual differences in personality.

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Although the original paper-and-pencil method of Mira y López was and is still used in more than 300 scientific works related to the MKP by Mira y López and his followers (Liutsko, 2013b) and in applicative practice; the computerized DP-TC test, created within the tradition of Mira y López, facilitates its application and measurements in the reduced, statistically proved, latest version (Tous, 2008; Tous et al., 2012). The test is administered individually for duration of 20-30 minutes. There are plans to issue English and Russian versions of the tests and the corresponding material.

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Original manuscript received January 29, 2014
Revised manuscript accepted June 01, 2014
First published online June 30, 2014

Psychology in Russia: State of the Art
Volume 7, Issue 2, 2014

Russian Psychological Society
Lomonosov Moscow State University

Methods of dichotic listening as a research methodology for hemispheric interaction

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Experimental data was obtained from a dichotic listening test by patients with unilateral brain lesions and corpus callosum pathology (agenesis, cysts, degenerative changes, etc). Efficiency index analysis shows that interhemispheric interaction in the audioverbal sphere depends to a greater extent on the right hemisphere state. The dichotic listening technique is not an informative means of studying hemispheric interaction, since it does not allow a clear distinction between hemispheric symptoms and symptoms of pathology of the corpus callosum. Thus, violations of hemispheric relations caused by disorders of the corpus callosum and cerebral hemispheres change worth more right hemisphere activity.

Keywords: interhemispheric interaction, brain pathology, dichotic listening

Dichotic listening is one of the most widespread procedures for studying interhemispheric interaction in the audioverbal sphere. Specific peculiarities of interhemispheric interaction during audioverbal information processing distinctly reveal themselves when analyzing the efficiency indices of dichotic stimuli reproduction (Goldberg, 2003: Moskovichute, Golod, 1989). For this reason, special attention is paid to analysis of the efficiency coefficient (the quantity of correctly reproduced words — C_{Ef}). C_{Ef} reflects each hemisphere's contribution to these processes. Total C_{Ef} is estimated in order to evaluate the efficiency of the reproduction of dichotic stimuli originally produced on both ears. C_{Ef} of the right ear and C_{Ef} of the left ear serve to evaluate the reproduction efficiency of words perceived by the right or left auditory canal to determine the quality of participation of the hemisphere that is contralateral to the ear in the audioverbal processes:

$$C_{Ef} = S / tqw \times 100\%,$$

where S is the the sum of correctly reproduced words, and tqw is the total quantity of sample words.

The experiment results and the estimated coefficient of the right ear (CRe), which is calculated by the following formula (Kotik, 1974):

$$CRe = (\Sigma Re - \Sigma Le) / (\Sigma Re + \Sigma Le) \times 100\%,$$

ISSN 2074-6857 (Print) / ISSN 2307-2202 (Online)

doi: 10.11621/pir.2014.0206
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