How the new technologies might lead to a paradigm shift in psychological and neuropsychological research.

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Abstract

Recently, we started to apply old psychological and neuropsychological standard tests and therapeutic exercises into a different domain of technology. Therefore, while maintaining the whole conceptual and logical structure of the traditional approach – i.e. tests mostly made by hand on paper or with the mouse and computers' screens - intact, we moved them onto the physical interactive and playful technology, Moto Tiles. Such a translation of input/output, likewise involving dissimilar perceptions and different parts of our motor system (i.e. legs, feet and balance system), might imply a change in subjects' mental and behavioural strategies, variations in efficacy and efficiency, as well as a redefinition of reaction times. In short, this shift, besides providing a significant extra tool to older practices, might work as a crucial test for all of the existing theoretical background, too. We describe our new method and report few of the first empirical applications.

Keywords: Playful robotics, Psychology, Neuropsychology, Therapy, Clinical Tests, New Paradigm.

1. Introduction

In both psychology and neuropsychology there are several tests and exercises that enable professionals to evaluate a large set of humans psychological responses to specific stimuli and try to measure or improve their abilities. This is true for both normal and clinical patients. These psychological tests have the great advantage of being properly validated and, as a consequence, they produce "an objective and standardized measure of a *sample of behaviour*" [1] with results that are very solid and steady. There is a large set of tests with different options and methods that differs between each other for at least three characteristics:

a) Trials used to measure abilities;
b) Trials used to improve abilities;
c) Domain of application.

Of course, a single test might cover up both (a) and (b) simultaneously while quite rarely a single tool can range from one domain to another (c).

In this pilot study we will only be considering psychological tests that focus on basic cognitive features and abilities domain, so excluding those that try to reflect or measure psychological entities such as aptitudes, emotions, personality, interests, IQ, etc.

Moving from this valuable tradition, we considered to transfer such consistent set of data and long lasting expertise that were originally implemented and validated with traditional tools (i.e. paper-and-pencil, mouse and computers' screen, and etc.) to a new and possibly common input/output flow, the Moto Tiles technology [2]. We look at this "translation" as a great opportunity for providing:

- A significant extra tool to older practices;
- A crucial test for all of the existing practice and theoretical background.
- A common platform (and consequently set of data) to all of the tests;

Sure enough, our transfer of input/output is to be verified and weighted, since besides requiring different perceptions, it implies the participation of different motor planning/acting systems (i.e. legs, feet and balance system). Therefore, this change in behavioural demand might imply a change in the subjects' mental and behavioural strategies, variations in efficacy and efficiency, as well as a redefinition of reaction times and some of the behavioural parameters.

Anyway, our effort should be rewarded by the advantage of moving on a common digital platform that can collect data from different experiments in a much more standardized way.

In this paper, we present a couple attempts to transfer old and consolidated tests from the psychological literature

regarding the *attentional system* in order to examine the feasibility of the above described methodology.

2. Inspiring Psychological Tests

The first set of psychological tests we moved from are two traditional tools used in clinical environments to evaluate subjects' attentional system efficiency. They are

- Line Bisection tests
- Visual Search tests

***2a**. Line Bisection tests*

The Line Bisection [3] is used in neuropsychology to quickly assess both the type and the severity of Unilateral Spatial Neglect (USN). Probably it is the most-used and quickest test for such a diagnosis; therefore it is popular, solid and efficient. It consists of a set of paper-and-pencil tests where a line (or more) a few centimetres long is drawn and the patient is then asked to dissect the line at the midpoint (see Fig. 1). Patients exhibiting, for example, left-sided neglect will respond with a rightward deviation of the line's true midpoint. The same test can also be used for normal adults [4, 5], so it might be seen as a more generic valuation of spatial attention efficiency in any subject.

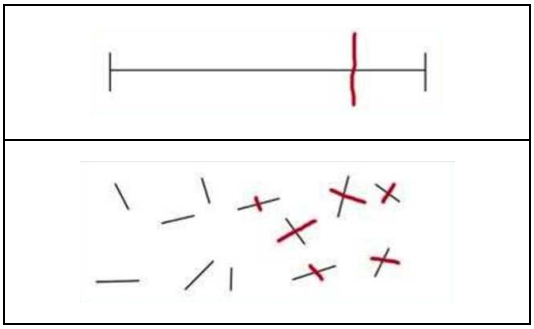

Fig. 1. Line Bisection tests. Up a single line test example. Down a multiple line test example.

2b. *Visual Search tests.*

The well-known visual search paradigm, designed to assess the function of visual attention, has had an enormous impact on many aspects of science. The vast majority of visual search studies performance is assessed with response times. Typically, the task is to determine whether a target is present or absent [6]. Search slopes that measure how response times change as more distractors are added to the display are presumed to assess the speed of the search and whether attention is involved or, clinically speaking, the efficiency level of a given subject attentional mechanisms.

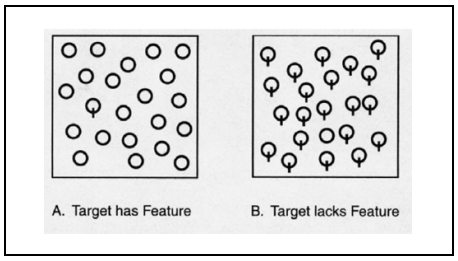

Fig. 2. Visual search tests.

This simple test is very predictive of subjects' efficiency on visual attention tasks, and, originally, it was a tool used by Treisman in defining is Feature Integration Theory (FIT) on *Selective Spatial Attention* [7].

3. Implementation of the tests on Moto Tiles

The two psychological tests described above were used as starting point and inspiration material for implementing respectively two new Moto Tiles games/exercises. Despite of the fact that, changing physical platform implies a crucial change on tests significance, we tried to keep as much faithful as possible to the original tests conception.

3a. *Neglect.*

The Neglect game/exercise is an attempt to transfer the psychological Line Bisection tests knowledge to the Moto Tiles environment. Neglect can be a single player task or a challenge between two players. The game indirectly measures the users' RTs (Reaction Times) and the general state of vigilance, and therefore might also be used as a therapeutic exercise for elderly and, in particular, for all of those patients with inattentive problems subsequent to a stroke, an ictus or degenerative neurological syndromes.

Tiles Configuration.

One tile is positioned in the (virtual) centre of the room and four in each side of it (left and right).

Fig. 3. Testing the *Neglect* game/exercise on Moto Tiles.

Lateral tiles can be positioned both in a squared shape (2*2) and in a linear shape (4*1, as shown in Fig. 3), accordingly to the kind data we want to collect or the game/exercise dynamic we want to impress.

Game Options.
The game options are to be selected on the tablet's software interface, and they are:

1. Number of players, one (for therapeutic reasons) or two (gaming);
2. Colour for each player;
3. Number of reiteration of the exercise/game;
4. Timing parameters (will influence the game difficulty);
5. Game start.

Game Dynamics.
Once the game is started from the tablet, the central tile is lit up with one of the two colours (in both one or two players sessions). To start the real section the player identified with that very colour has to smash it to start the real sub-section. At that point, one of the 8 lateral tiles (pseudo-randomly chosen) will be lit up for a short time (to be defined accordingly to gaming and therapeutic sections) and the goal of each individual (either in a single player or in a one-to-one section) is to squeeze it as fast as possible (using one of its feet). Timing is calculated and a threshold applied so that after a given number of milliseconds the lit tile, if not squeezed, is turned off and at that point, whatever case occurs, another tile is lit up. Such an operation is reiterated for 8 to 16 times (also accordingly with section's purposes). After that, in the case of one-2-one competition, the central tile is lit up again, with the other colour, and waits for the new sub-section to be started. At the end of the second section the tablet calculates the shortest timing and provides a visual feedback that underlines the winner. In the single player case the game/exercise simply comes to an end.

The one-2-one game/exercise is pretty dynamic, very easy to understand and quite funny. It is to be highlighted that, in both cases, the level of difficulty can also be tuned by shaping the morphology of the playground (lateral tiles are positioned far).

3a. *Special Pattern* or *Special One.*
The *Special Pattern* game/exercise is an attempt to transfer the psychological knowledge on visual search tests in our Moto Tiles environment. In short, *Special Pattern* can be used as a single player task or a challenge between two players. In the one player version four tiles are positioned in a linear (4*1 tiles) or squared shape (2*2 tiles), while in the one-2-one version everything is doubled.
Gam
e Options.
The game options are to be selected on the tablet's software interface, and they are:

1. Number of players, one (for therapeutic reasons) or two (gaming);
2. Colour for each player;
3. Number of reiteration of the exercise/game;
4. Timing parameters (will influence the game difficulty);
5. Pattern discrepancy (level of difficulty in terms of physical/visual distance between different patterns);
6. Target Feature. The target tile lacks or has a special feature (will influence the game difficulty and target analysis);
7. Game start.

The patterns correspond to different configuration of the activation of the LEDs within one tile (see Fig. 4 for some examples).

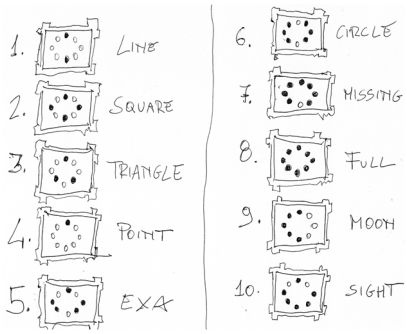

Fig. 4. Designing the *Special Pattern* game/exercise.

Game Dynamics.
When the game is started all the tiles are lit up. But three out of four tile will show the same pattern, while the fourth one will show a different pattern. The user(s) have to react as fast as possible to try to crush on the "different" tile's pattern amongst the four (neglecting the three which show the very same patterns). The game/exercise keeps on rolling like that up to the last stimuli set. At the end it provides a visual feedback that shows the winner of the one-2-one competition or, for the single player option, provides a visual feedback about the performance.

Both versions of the game/exercise, also accordingly to the options tuning made at the start when the play is configured, result in a quite effort-demanding increase of attention and/or visual search. The one-2-one version, in particular, when timing gets crucial, has been reported and turns out to be mentally speaking deeply challenging.

4. Knowledge transfer

We tried to move a couple of tests regarding Spatial Attention and Visual Search from the old paper-and-pencil school, normally used in psychological

experiments, to a new realm of technologies. Since these new technologies (i.e. the Moto Tiles) are made of digital and electronic devices and as input/output demand for a pretty different set of perceptions and action, our biggest effort is to try being as faithful and coherent as possible with the former experience and knowledge. It is too early to think of a significant outcome, though we believe we are going in the right direction. This is because the Moto Tiles technology has shown to be very adaptive to different tasks' specifications and demonstrated to be practically very close, as behavioural practice, to the original methods used.

In particular, we believe the *Neglect* task we have built, while not superimposable to the *Line Bisection* task, it should require a similar amount of spatial attention, specially if compared to *Multiple Line Bisection*, and a comparable in terms of precision/effort of action in physical space.

The *Special Pattern* task seems to be even closer to the corresponding Treisman's figure integration test, since it seems to require both a similar demand of selective spatial attention and the same precision/effort of action in physical space.

Of course, the two games/exercises might need to be perfected, integrated with additional features or fine tuned, and that's why at the very moment we are in the process of building a number validation tests in which we will compare data from traditional tests with those from Moto Tiles in a group of human subjects

5. Discussion

In this paper we depicted one method to move old psychological and neuropsychological knowledge in to a new technological tool. This is not a fully new experience since in the past the old pencil-and-paper psychological tests have been brought into software-based environments, see [8] for an example. Therefore, our attempt is just one more step towards digitally based tests, but with a little stronger stress on the standardization of the tests data and physical representation of the test tool.

Our main goal is to bring old findings regarding brain oriented clinical diagnosis and therapy to a new domain of technology, the Moto Tiles, which would allow us to collect data, as well as run trials and therapy exercises, in an environment that is basically standardizable, highly stimulating and playful, as we know from our former experiences [2, 8]. In doing this we are limiting our experience to a specific subset of possibilities, visuo-attentional tests in the cognitive domain of Psychology.

This is because we believe that the Moto Tiles game/exercise can be, in general, very predictive of the general state of sensory and motor alertness of anybody [2] and, in the particular case of neurological patients, might measure the state of the attentional system quite efficiently.

The actual state of the art is that we have built two games inspired to two corresponding traditional psychological tests, whose methodology has been shown here, and we are in the process of validating them with an empirical case study.

Of course, if such a pilot experiments will result positive, we intend to move on to a larger panorama on cognition (e.g. perception, memory, sound, and etc.) and, further, on different psychological domains (e.g. aptitudes, emotions, personality, interests, IQ, etc.).

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