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Appropriate Technology in a Resource-Poor Setting – A Case Study of Locally Fabricated Anxiety Research Tools

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***Abstract*— Anxiety disorders are among the most prevalent mental diseases globally and the currently available anti-anxiety drugs are few and are encumbered with individual limitations. This scenario calls for the discovery of additional novel anxiety-alleviating drugs. To bridge this need gap, some African plants with traditional anti-anxiety effect were to be screened for their in-vivo anxiolytic efficacy using standard behavioural tools. But in resource-poor settings like Nigeria, many anxiety test apparatuses are eitherphysically unavailable norfinancially unaffordable, hence the need to embark upon local fabrication of units of the mouse elevated zero-maze and staircase apparatus. The unit cost of the end products of the fabrication exercise is found to be less than 5% of that of their imported counterparts against which they compare favourably well in safety, operationality and rodent anxiety sensitivity. There is the need forwidespread growth of such appropriate technology to engender greater self-reliant research in behavioural and other medical sciences on the African continent.**

***Index Terms*— adaptive, behavioural, elevated zero-maze, mouse, staircase apparatus.**

I. INTRODUCTION

The ever-increasing gap between the high global prevalence of anxiety-related disorders and the shortage and shortcomings of the existing anxiety-alleviating drugs calls for the discovery of additional novel anti-anxiety agents (1, 2). The paucity of the existing anxiolytic drugs and the slow pace of discovery of additional new ones, globally and especially in a resource-poor setting like sub-Saharan Africa,can be partly due to low-level activity in behavioural neuroscience research which may, in turn, be traceable to the dearth ofrelevant neurobehavioural(anxiety) tests or models. Behavioural science typically makes use of severalexperimental set-ups,tests or models to induce and/or detect anxiety in an animal to gain insight into human anxiety disorders and also to evaluate anxiety-modulatory effects of known and putative anxiolytic drugs. Thisspecialised medical field has been largely recognised as an indispensable component of the preclinical stages of psychoactive (including anxiolytic)drug discovery (3).

To reduce the gap between the high anxiety disorder prevalence and the presently available anxiolytic drugs, extracts of selected African medicinal plants with anecdotal reports of anti-anxiety effects were to be screened for their anxiolytic potentials using three of the most popular in-vivo mouse anxiety tests/models i.e. elevated zero-maze, staircase and open-field tests. However, the study was confronted with the challenge of sourcing the multiple units of elevated zero and staircase test apparatuses needed to execute the behavioural experiments. Multiple units of these test apparatuses were needed to generate test batteries that would facilitate throughput and the use of a minimum number of animals since simultaneous testing of the different mouse experimental groups would then be achievable. Parallel testing was thought necessary to reduce to the barest minimum the temporal biases that could arise should the experimental groups be tested at different times, one after the other, instead of simultaneously. But two of the three test apparatuses required for the study i.e. elevated zero-maze and staircase were not available locally. The use of multiple (at least 3 different) standard mouse anxiety tests in the experimental design for the anticipated in-vivo anxiolytic efficacy study was to enhance the chances of detecting broader spectrum of rodent anxiety indices since previous studies indicate animal anxiety tests/models have individual anxiety-detecting idiosyncrasies (4, 5). The alternative way around this challenge of non-availability of multiple units of the test devices was to import them but the unit cost ofabout 1900 USD ofthe foreign versions of the 2test toolswas way beyond the budget of the entire study. This was apart from theextra fund, time delay and other unforeseen logistics that could arise from their importation. Hence, the need to look at the possibility of using locally available and affordable raw materials to fabricate anxiety test apparatuses that would have the capacity to generate reliable rodent anxiety indices.

II. MATERIALS AND METHODS

A. *Materials*

One 4-mm thick polyvinyl glass sheet (4 x 2 m) (N18, 000:00k, 50 USD), two 2-mm thick polyvinyl glass sheets (4 x 2 m)(N28, 000:00k, 78 USD), 2 deep lemon-coloured 4-mm thick fibre glass sheets(4 x 3 m) (N15000:00k, ≈42 USD), 2 glass cutters (N700:00k,≈2 USD) 6 plastic containers of Evostic gum (N9000:00k, 25 USD), 3 units of adhesive putty (N1800:00k, 5 USD), 10 rolls of super glue (N3700:00k, ≈10 USD), metal measuring tape (N1500:00k, ≈4 USD), metal file (N1000:00k, ≈3 USD), sand paper (N350:00k, ≈1 USD), soldering iron (N3500:00k, ≈10 USD), bolts and nuts ((N1050:00k, ≈3 USD), 10 pieces of PVC

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pipes (N3600: 00k, 10 USD) and paints (N2700:00k, 7.5 USD), were all purchased at a local market (DugbeAlawo) in Ibadan, the capital city of Oyo state, Nigeria.Transportation, 8-day workmanship for 2 persons and other logistics (N110, 000:00k, ≈306 USD).

B. *Fabrication procedure*

Elevated zero-maze

With the aid of the glass cutters, the 5-cm broadcircular runways of the elevated zero-mazes (EZM) with an outer diameter of 61-cm were carved out of the large sheet of 4-mm thick polyvinyl glass. Next, the outer (40x19 cm) and inner (30x19 cm) walls of the EZM were also carved out. Rough edges of all cut-out pieces of glass materials were smoothened by the use of metal files and sandpapers. Each piece meant for a wall of the EZM was moulded into the desiredcurvature by gently bending it over a flame, to soften it, and then quickly moving it away from the heat source to assume a permanent curved cast. Pieces of 40 x 0.5 cm and 30 x 0.5 cm 2-mm polyvinyl glass were also cut out to serve as curbs on the outer and inner edges of the open segments of the EZM, respectively. The circular runways were then marked into 4 equal segments, and with the aid of anadhesive mixture made from a combination of adhesive putty, Evostic gum and super glue, the lower ends of the 40 x 19 cm and 30 x 19 cm walls were attached to the outer and inner edges, respectively, of two opposite segments of the EZM and held in place till they were completely dry. Similarly, the curbs were also attached to the outer and inner edges of the remaining open segments. The stands of the EZM were constructed thus; each zero-maze (with the circular runway and the walls in place) was placed upside down on a flat surface. With the aid of the adhesive mixture, four short 2.5-cm wide PVC pipes were attached at one of their ends to the undersurface of the circular runway such that each anchor pipe is directly beneath the edge of a closed segment. The anchors were allowed to dry overnight. Next, equal-length 2-cm PVC pipes were each inserted into the 2.5-cm anchors to form a 4-legged stand. The stand was further strengthened for balance by bolts with nuts and plastic braces at the topand lower portions of the legs, respectively.

Finally, a thin layer of fine glass pebbles was plastered to the entire length of the circular runway surface by the aid of the adhesive mixture. This was included to facilitate easy ambulation of the test animals. The runway with the curbs was painted light blue while the walls and the stands were painted black.

Staircase apparatus

With the aid of the glass cutters and measuring tape, a large sheet of 0.4-cm lemon colouredfibreglasswas cut into various sizes such as 45 x 30 cm, 10 x 30 cm, 10 x 45 cm pieces for the outer casing of the staircase box. Other fibreglass cuttings meant for the steps within the box included 5 pieces of 7.5 x 10 cmfor the 0.4-cm thick step floors, 2 pieces of 12.1 cm, 9.6 cm, 7.1 cm, 4.6 cm, and 2.1 cmglass cuttings for the step supports.Next, the 45 x 30 cm, 10 x 30 cm, 10 x 45 cm pieces were joined and held together by the adhesive mixture until the adjoining portions were completely and firmly dry and bound together. In this way, the 45 x 30 cm pieces formed the lateral walls, the 10 x 30 pieces formed the rear and anterior walls, and the 10 x 45 cm pieces formed the floor, of the box-like apparatuses.Next, the five steps of the device wereconstructed through its open roof. The support bases of the steps were first erected before placing the 7.5 x 10 cm floors on them. Placement of the 0.4-cm thick glass floors was started from the distal end of the box with the highest stepsupport of 12.1cm and then proceeding proximally with 2.5 cm reduction in heights at successive steps until the lowest at the height of 2.1 cm, thus,producingcumulative step heights of 12.5, 10.0, 7.5, 5.0 and 2.5 cm, respectively. Again, all the glass pieces were held firmly in place by the use of the adhesive mixture until the whole contraption became a solidified unit. The floors were overlaid with thin layers of fine glass pebbles held in place with the aid of adhesive mixture. This aspect was included to facilitate easy ambulation of the test animals.

III. RESULTS

Eight elevated zero-mazes were generated (Figures 1, 2 & 3). Each consists of a 5-cm wide circular runway with 2 closed and open portions alternating on equal segments of the zero-maze supported on a 4-legged stand. Seven units of staircase apparatus were generated (Figures 4&5). Each consists of transparent open glass 45 x 30 x 10 cm box with a 5-stepped floor. The most distal and proximal steps are 12.5 and 2.5 cm, respectively. Each step floor is 7.5 cm deep and 10 cm wide.Total and unit costs for the 15 test apparatuses are 556.5 USD and 37.1 USD, respectively.

Figure 1: elevated zero-maze

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Figure 2: aerial view of units of the elevated zero-mazes

Figure 4: aerial view of a staircase apparatus

Figure 3: units of zero-maze with collapsed stands stored away

Figure 5: units of staircase apparatus stored away

IV. DISCUSSION

This exercise presents one of the few reports on the local fabrication of animal behavioural test tools in general and mouse anxiety test devices i.e. elevated zero-maze (EZM) and Staircase apparatus,in particular.EZM and staircase models are not only among the most useful and well-validated rodent anxiety tests but have also been shown to be fast, sensitive and proficient tools in anxiety drug discovery efforts (6, 7, 8, 9). Additionally, EZM test is

viewed to be an improved version over even the most frequently deployed anxiety test – the elevated plus-maze test - due to the absence of a confounding central square in its design.(10).

The local production of these apparatuses with the intent to harness theirinherent strengths to bridge a local biomedical research gap can be viewed from the standpoint of appropriate technology – a term which has been generally agreed to mean a technology (hardware and skill)that is evoked, evolved, developed and/or adapted in response toa particular circumstantial need or set of needs(11, 12).

It is worthy of note that our experimental and other experience through the use of these fabricated products indicate high compliance with most of the characteristics recommended for a technology to be deemedappropriate to a particular setting.These anxiety test tools have been observed to exhibit high operational simplicity. They are easy to set up and their experimental procedures easily comprehensible by the users – including even the supportive laboratory staff. Also, their operations are not dependent on complicated infrastructures – including automation (although this can minimize user errors). Furthermore, these devices could be easily moved from place to place, easily maintained and cleaned up with 70 % ethanol and easily dismantled and/or stored away after use (Figure 3& 5)- and easily assembled back when the need arose.

Another high point to these fabrications is their safety to the users with no negative environmental impact since the different components are inert and non-toxic. Yet, another strong point to these test tools is the low capital investment required to put them up. They do not require more than the size of a room to fabricate, the materials were all locally availableand affordable. There was no need for sophisticated machinery in their fabrication other than a few hand tools from start to finish. Perhaps the greatest attraction to these appropriate technology products is the low unit production cost. The eight units of elevated zero-maze and the seven units of staircase apparatus were produced at an estimated total and unit cost of 556 and 37 USD, respectively. This is a far cry from the unit cost of about 1900 USD of the foreign versions of the same set of tools.Previously,a low production cost of items and services, among other factors, has been pointed out as a huge attraction to appropriate technology especially in developing or economically poor nations like Nigeria (11, 13).

Finally, these fabrications have demonstrated high productive capacity so far. The anxiety indices obtained from behavioural studies using these devicescompare fairly well with those obtained from other studies using similar but imported behavioural test apparatuses (14, 15). This position is buttressed by the findings in relatedprevious studies using locally fabricated behavioural instruments where the results yielded thereof are similar to those gotten from foreign behavioural equipment (16, 17).

V. CONCLUSION

The two mouse anxiety test devices i.e. the elevated zero-maze and staircase apparatus, manufactured in Ibadan, Nigeria,from local raw materials, are safe, easy to use and highly affordable. These assets combined with their capacity to generate reliable behavioural indices will serve as an impetus to trigger further interest in the local production of research tools in behavioural and other medical sciences. This developmentwill ultimately culminate in the growth of self-reliant research activity on the African continent.

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