

Working Memory and Non-Verbal IQ-Clinical Implications

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Abstract: This is a short clinical mini-review paper discussing a measure of cognitive importance, working memory. Working Memory (WM) refers to the capacity to store and manipulate information for a very short period of time. It is a cognitive workplace for processing simple or complex information and mental tasks. Working memory capacity is measured by complex span tasks that requires simultaneous short-term storage of information while processing additional information. WM has been shown to have influence on IQ testing. Here we discuss the clinical implications of WM on understanding, and reaching diagnostic evaluation of nonverbal IQ in adults. This short review suggest that clinicians (particularly in non-English speaking population- such as Arabic countries) should consider WM before diagnosing a patient with mental retardation, or IQ deterioration, for instance, based on nonverbal IQ only. The clinical implications are also discussed.

Keywords: Working memory, IQ, Nonverbal IQ, Neuropsychology, Saudi Arabia.

INTRODUCTION

Among a number of concepts dealing with higher level of cognitive processing, the Working Memory (WM) [1, 2] is an important concept in cognitive neuropsychology and cognitive neuroscience. WM refers to the “central” structures and processes that temporarily maintain, store and manipulate information for supporting human thought process, not just memory. Working memory, however, has very limited capacity system: it allows us to keep an “active” limited amount of information for a brief period of time, and to operate on it by mainly processing not storing [1]. We apply WM when we rehearse a phone number until we dial it, or recall different paths to a destination and compare them in our minds in order to select the shortest one. In particular, WM permits us to temporarily maintain task-relevant information during performance of complex cognitive tasks, such as reasoning, planning, manipulation of linguistic information. It also helps the executive control and coordination of perception and action in complex cognitive operations [1-3].

In addition, WM provides an interface to long-term memory (LTM) [3]; that is instead responsible for the “passive” storage of information for longer periods of time: WM can “upload” and “download” information to and from LTM. The emphasis on active manipulation rather than on solely storage of information, distinguishes working memory theories from those of short-term memory (STM) [1, 2].

It is generally accepted that working memory is conceptualized as multi component: it includes a central component, the central executive, and three sub-systems: the phonological loop (verbal), and visuospatial sketchpad, and the episodic buffer [2, 6]. The central executive part allows one to execute plans and direct attention, as well as supervising other components for the WM. The visuospatial sketchpad permits a manipulation and maintaining visual and spatial information. The phonological loop allows the auditory (verbal) information to be rehearsed for very short time and prevent it from disappearing form consciousness. While the episodic buffer works on integrating all components for processing and allows a temporal representation [1, 2]. We are mainly concerned here with adult work however, for the effect of WM on normal children or children with developmental cognitive abnormalities or academic achievement; see other sources (e.g. [4, 5]).

Clinical research and neuroimaging of the recent years have provided good understanding of the WM [3, 6]. The phonological lobe for instance was, predictably, associated with the frontal lobe and related to language areas as well (both Wernickes’ and Broca’s areas). While the visuospatial pad related to the occipital parietal lobe- dealing with visual and spatial information processing.

In clinical practice, where the scope of this small paper is intended, usually WM is assessed as routine part with a neuropsychological assessment. Here patients are assessed on their intelligence, memory, language, visuospatial and executive functioning, as well as psychological status. The accurate comprehensive assessments yield a good clinical profile of the

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cognitive neuropsychological functioning of the patient in clinical settings. Patients can suffer from either a developmental deficits (ADHD, etc) or acquired brain insult (e.g. stroke, TBI, or tumour). This is followed by neuropsychological diagnoses and management- such as cognitive rehabilitation [9]. In Arabic countries and non-English speaking cultures often neuropsychologists use non-verbal IQ tests to reduce the cultural, language and educational influence on IQ tests. This leads clinicians to reach clinical diagnosis based non-verbal IQ. We have a significant concern about the utility of such tests with no reference to other cognitive factors, such as WM.

TBI patients, among many brain injury sufferers, often have difficulties with speed and not with simple visual processing free of time stress (nonverbal IQ tests, e.g. TONI, Ravens'...). Patients therefore, score better on simple visual nonverbal IQ task, compared on complex time-limited or complex reasoning [9].

A CLINICAL CASE

A 32 year old male with high school education was seen for cognitive neuropsychological assessment after a mild TBI that took place about 18 months ago. Prior to that he was healthy and normal on all accounts. He had no cognitive or psychological problems at all before the TBI. His performance on the IQ (Wechsler Adult Intelligence Scale-WAIS- Arabic) test was within average range (FSIQ =95) for his age and education. His language skills were normal. But he was impaired (IQ=73) on nonverbal IQ (Test of Nonverbal Intelligence Test -TONI- culture free task), as well as on Digit Span- from IQ subtest from WAIS, a working memory task (scaled score=6; while average is expected scaled score=10). This raised the point of dissociation between his IQ results on the WAIS and the nonverbal IQ. How could someone with such normal IQ to be impaired on easier time-free motor-free nonverbal IQ? How can this be explained in neuropsychological terms?

WM AND COGNITIVE FUNCTIONS

It is widely known that WM is measured by a number of tasks, visual and verbal. Digit Span task is accepted as one common task measuring verbal WM in clinical and research practice [9]. Clinically, this is an easy valid and reliable task to measure WM. The above clinical example, highlighted the possible role of the WM on processing visual spatial information. It has been hypothesised therefore, that this cognitive

discrepancy can be accounted for by the notion that the ability to reason and solve problems requires the use of information held in working memory, and this information by its nature can be subjected to loss (due to either decay or interference). As a consequence, faster processing is more likely to permit reasoning to reach completion before the requisite information is lost [10]. Therefore, patients' performance on IQ tests (including nonverbal) may be effected by the working memory deficits (or strength) [8, 11].

The fact that nonverbal tasks involve visual processing that means the WM is certainly also involved. Recent research has shown that fluid intelligence (such as nonverbal IQ) is correlated to WM [3]. This in fact explains our patients' performance dissociation between the nonverbal IQ (fluid intelligence) [8] and the Verbal IQ. WM required to hold visual information [the visuospatial sketch pad) in order to solve the visual problem. The deficit on WM (indicated by low Digit Span) was at least in part responsible for low nonverbal IQ. Furthermore, research have suggested that WM is very good predictor of IQ, both verbal and nonverbal. In fact, it is better predictor of academic achievement too (for more details; [4, 5]. Therefore, it is likely that WM in clinical practice would also be significantly associated with IQs and other cognitive functioning.

CLINICAL IMPLICATIONS AND CONCLUSIONS

This small clinical mini-review and discussion paper, suggests that WM is a significant cognitive neuropsychological component that impacts a number of other cognitive functioning [2]. It also showed that WM is particularly influencing the performance on nonverbal (fluid) IQ tasks [7, 8, 11].

In clinical practice, it is common that we use nonverbal IQ tests for patients with different cultural background, or who have significant verbal deficit following brain injury (e.g. TBI, CVA) and thus testable only on nonverbal IQ tests. The clinical implications from the above theoretical bases are wide and very important. Clinicians should not judge patients' IQ mainly on nonverbal testing, but also they have to consider WM. If patients are showing poor WM, they may also be expected to show poor nonverbal IQ [see 8, 11]. Thus the validity of the nonverbal IQ testing is compromised here. In fact, this limits the ecologic validity of our nonverbal IQ findings; therefore, we see patients who are independent and functioning well in

life in general, however impaired significantly on nonverbal IQ testing. We propose here that WM is both essential in assessment, and hypothesis that WM is important in interpreting nonverbal IQ tests and reaching the diagnostic conclusion. Future research and better data from group of similar patients will add more knowledge and guidance to the nature of WM and its link to nonverbal IQ.

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