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# Manufacture and Validation of New Negative Priming Measurement for Studying Individual Differences in Working Memory

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## Abstract

The Negative Priming task is widely used to investigate attention inhibition observed in some variations of a selective attention task. This study was designed to measure the reliability of a negative priming effect as a prerequisite for conducting this research. The sample included 100 university students whose ages ranged between 18 to 36 years. They completed two tasks: an identification task and a localization with episodic retrieval tasks. Subjects were asked to perform a simple mental operation on each stimulus, and to use the end product of this operation when deciding on a response. The subjects' task was to respond YES to a fixed set of three target items (e.g., numbers 2, 5, and 7) in two interval trials. To achieve the factor structure model validity, the data method and varimax rotation was applied. Results showed high correlation between variables and also six factors as the clusters were considered: 1) Target identification accuracy; 2) Location error; 3) Two seconds right error; 4) Three seconds right error; 5) Three seconds left error and 6) Two seconds left error. The reliability of the components were acceptable.

*Keywords:* negative priming measurement, inhibition, working memory, validity, reliability

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Computerized neuropsychological assessment has integrated slowly into research and practice since the introduction of the personal computer. By the mid-1980s, neuropsychologists had transferred paper-and-pencil measures to a personal computer platform and were exploring the equivalence of these measures to traditional tests (Eckerman et al., 1985). Numerous specialized tests are either used individually or as part of a battery. In addition, these tests are appropriate for different age groups ranging from infants to elderly people. (Goldstein & Beers, 2004). Age and education where significantly related to neuropsychological performance. But gender, however, was a moderating variable only for the elderly group. Some neuropsychological assessment tasks can assess cognitive dysfunction in humans which show unusual negative priming effect in tasks that can measure the negative priming effect. There is a large body of research establishing the NP (negative priming) effect. However, there are disagreements over interpretation of the findings. Theories attempting to explain NP include: selective inhibition; feature mismatch; episodic retrieval; and temporal discrimination. The selective inhibition and episodic retrieval accounts have received the most support. (Hsieh & Tori, 2007)

The negative priming task is widely used to investigate attentional inhibition. A critical review of the negative priming literature considers various parameters of the task, the review suggests that negative priming can be

produced by 2 mechanisms: memory related and inhibitory. With respect to inhibition, the review suggests that (a) there are 2 systems, one responsible for identity and the other for location information, and (b) inhibition is a flexible, post-selection process operating to prevent recently rejected information from quickly regaining access to effectors, thus helping to establish coherence among selected thought and action streams. (May, Kane, & Hasher, 1995 ).

The former account attributes NP to the inhibition of distracting information in the prime display and has been the preferred theory to explain NP findings in clinical research. On the other hand, the episodic retrieval account attributes NP to slowed processing of a probe target that was encoded in the previous processing episode (i.e., prime display) with conflicting response information (e.g., ‘‘do-not-respond’’ tag) (Amir, Cobb, & Morrison, 2008).

Negative priming consists of slowed reaction times and/or less accurate responses when people have to respond to a target that was ignored on a previous trial. On the basis of available data two main theoretical views have been proposed in order to explain negative priming. Inhibition-based models postulate that negative priming is due to the inhibition of irrelevant information after prime presentation that results in an impaired processing when such information becomes relevant during probe presentation. The episodic retrieval account proposes that the presentation of a stimulus leads to the automatic retrieval of information attached to the most recent episode related to that stimulus, including whether to make a response or not. When a distractor in the prime trial is presented as a target in the probe trial a conflict between the present and the past status of the stimulus arises. The resolution of this mismatch causes a delay in response. An attempt to integrate inhibition and retrieval perspectives was made by Tipper (2001, cited in Hinojosa et al., 2007).

Many negative priming paradigms are used in the study of attention and inhibition (Mulligan & Wiesen, 2003). Over the last fifteen years, numerous research has focused on inhibition and its function in various cognitive processes such as selective attention (Neill, Valdes, & Terry, 1995), memory (Anderson & Spellman, 1995) and lexical access (Simpson & Kang, 1994). When referring to inhibition, we mean a mechanism that reduces the activation of stimuli that are extraneous to the ongoing mental processes (Hasher & Zacks, 1988). The main reason for the great interest in this subject is because of its powerful role in explaining individual differences. A deficiency in inhibition has been reported both in children and older adults, in Alzheimer, schizophrenic and depressed patients and in patients with frontal lobe brain disorders (Harnishfeger & Bjorklund, 1994; May et al., 1995; Bestgen & Dupont, 2000).

The available literature on inhibition is paradoxical. On the one hand, research on the negative priming effect stresses that the function of inhibition, as evidenced by negative priming, is not to help interference resolution and that there is no consistent relationship between them. On the other hand, psychometric research that focuses on the role of inhibition as a mediator of aging, disregards negative priming measures and uses interference scores (Kwong See & Ryan, 1995; Salthouse & Meinz, 1995). The plausible and useful function of inhibition in selection tasks that involve the active inhibition of the distractor can be seen to prevent stimuli in irrelevant locations to gain control of action (Tipper, 1985; Tipper & Cranston, 1985). Inhibition can be observed in schizophrenic patients (Minas & Park, 2007) and lower negative priming in ADHD demonstrate higher levels of interference and lower negative priming effects in comparison with age – matched peers. (Pritchard et al., 2007).

Poor performance on a negative priming test can be an indicator of cognitive disorder. This test can assess multiple cognitive performances simultaneously. In most existing tests, the individuals face a distracter while the present test makes the individuals think of three things and react to them simultaneously. Since tests of memory and

cognitive performance are scant in Iran, developing new and up–to-date tests will contribute to the academic studies in this field. Compared to dependable studies done on similar tests, it seems that the present test can simultaneously assess multiple cognitive performances. In most existing tests, the individual faces a distracter but the present test makes it possible for the individuals to simultaneously focus on three stimuli and react to them. Through this test, it is possible to estimate the time needed for an ordinary individual to show proper reaction in the brain. Therefore, the major research question is to examine the reliability and validity of the negative priming task for probing into the attention inhibition and brain functions including working memory, speed of information processing, selective attention and concentration.

## Methodology

The present study aimed to design a prototype of and develop a cognitive measure for normal people and examine its psychometric characteristics.

### Research Participants

The population is students of Humanities and Mathematics studying in Shahid Rajaee Teacher Training University Located in Tehran/Iran in the academic year 2011-2012. The sample consists of one hundred students, fifty males and fifty females, ranging between 20 and 36 years of age selected as an available sample. Also 52 participants studying in Math education and Applied Math were also selected from in school of science, and 48 students in Instructional Management, Curriculum, English Language and Educational Psychology were selected in humanity school. Volunteers participating in the test were ensured that information will remain confidential.

### Procedure

The subjects sat relaxed in an armchair in front of the computer monitor. On the screen, there randomly appeared 60 numbers; 20 on the right, 20 in the middle and 20 on the left. For example, two numbers may appear on the right, one on the left or one on the right and /or three or four in the middle. The test material is presented in random. If an individual decides to sit for the test immediately after the first attempt, the arrangement of the numbers differs from the previous administration. The test is administered in two steps with 3 second and 2 second intervals. Before taking the test, a practice test is introduced. The responses (correct, wrong, no response) are recorded in the table, designed in the test, that appears at the end of the test. The responses and the demographic information of the respondents are recorded separately in a file for every participant. They were told to add +1 to get the numbers right, numbers that appear in the middle of the monitor are neutral (not add, not subtract) and the numbers on the left you see a minus one. If the answer was 2, 5 or 7, click the right button. For example you can see on the right of screen number 6 (the instruction was adding 1), in this case number 6 plus 1 equals 7. One of the target numbers was 7, so you should click the correct number. On the left hand of the screen, if you see number 3 (the instruction was minus 1), and in this case 3 minus 1 equals 2. Numbers in the middle side of screen remain the same without any changes and just three target numbers (2, 3, and 7) should be clicked.

Also in order to get concurrent validity, Paced Visual Serial Addition Test (PVSAT) which is performed in 2 and 3-second tries was performed. The interval between stimuli in the first try was 3 seconds and in the second try was 2 seconds. The participants should add up each number with the preceding number and vocalize the result. Then they have to add up the last number displayed on the screen with the coming number and then announce the result. The test goes on like this. The maximum number of correct and incorrect answers is 60.

**Instrument**

1) **Negative Priming Test**: Various negative priming tests assess individuals' cognitive abilities such as selective attention, speed of information processing and working memory through imposing some distracters. Priming paradigm is a commonly practicable instrument for assessing the internal representation of the newly introduced stimulus. This test makes it possible to measure the reaction time for the ordinary people to do the tasks. In present negative priming tasks there are some inhibitors for attention such as doing some simple arithmetic operations like adding or subtraction of numbers with different randomize appearance locations on the monitor screen (on the left, middle and right location) without any orders. The test makes it possible to assess the reaction time for correctly performing mental activities such as adding or estimating the fraction of numbers appearing on the screen by different groups of people including the retarded, those with mental disorders such as Multiple Sclerosis, Alzheimer's, hyperactivity, mentally suffering people and normal individuals of different social classes, gender, educational background and in special circumstances, for example stressful states because this test can assess the speed of reaction in 1 up to 10 seconds.

**2) Paced Visual Serial Addition Task (PVSAT)**: In order to estimate concurrent validity of NP test, PVSAT a measure of cognitive function applied. PVSAT specifically assesses auditory information processing speed and flexibility, as well as calculation ability. This test proves a demanding test, which PASAT is an audio version of the Paced Serial Addition Test (PASAT) that was first used as a measure of health and performance of the brain of the individuals whose head had been stricken and later the test was used as a classic measure of concentration and information processing. Research has shown that PASAT has been utilized as a measure of working memory, speed of information processing. Keeping and dividing the concentration (Spreen and Strauss, 1998). PASAT and PVSAT also are applied for both clinical and research purposes. These tests had originally been developed for assessing the change of efficiency of brain during the recovery period of head injuries, for example brain damage that leads to unconsciousness. At the present time, however, the test is used with various clinical diseases such as brain injuries (Brooks, Fos, Greve, & Hammond, 1999; Gronwall, 1977), multiple sclerosis (DeLuca, Chelune, Tulsky, Legenfelder, & Chiaravalloti, 2004; Miller, Rudick, Cutter, Baier, & Fischer, 2000), tuberculosis (Shucard et al., 2004) aching disorders (Sjøgren, Thomsen, & Olsen, 2000), cancer (Sjøgren, Olsen, Thomsen, & Dalberg, 2000, hypoglycemia (Schächinger, Cox, Linder, Brody, & Keller, 2003), and asthma (Weersink, van Zomeren, Koeter, & Postma, 1997). The present test exhibits sensitivity to cognitive disorders accompanying Multiple Sclerosis (Diamond, DeLuca, Kim, & Kelley, 1997). The visual version of concentration level test, developed in 1956 by Sampson who developed the audio version of PASAT in the same year, is introduced as PVSAT. Since various studies have proved the PASAT exhausting (e.g., Fos et al., 2000), in recent years developments in technology have brought about new versions of visual tests (PVSAT) in which personal computers are used for displaying the stimuli (Nagels et al., 2005). Fos, Greve, South, Mathias, and Benefield, H. (2000) have predicted that interference between input and output data in PVSAT is less than PASAT. That is why the patients see PASAT tougher than PVSAT.

The visual version (PVSAT) is administered like the audio model, through the figures appearing on the computer monitor. Also, in the two trials, time for the presentation of figures has marginally changed. That is to say, instead of 2/4 seconds, the time lapse of figure presentation is 3 seconds and instead of 1.6 second of display, the figures are displayed for 2 seconds. Studies have reported the reliability of PVSAT to be more than 0.90 (Egan, 1988) and internal consistency and test–retest reliability between .97 and .93 (McCaffrey et al., 1995). The reliability of the present test, estimated through test-retest method, turned out to be 0.91 (Hamidi & Noorafkan, 2011).

### Data Collection

First, the computerized test was developed using the existing protocols then it was administered to 100 students. The subjects were interviewed over their demographic status and were given a sensory nerve disorder test followed by the present test. The data were recorded in a table. After a one month interval, the test was re-administered to thirty subjects, 15 males and 15 females of the same sample to estimate the reliability of the instrument. Paced Auditory Serial Addition Test (PASAT), an already established test, was administered in order to estimate the validity of the test.

## Results

In order to estimate the validity of the Negative Priming test, use was made of construct validation procedure. To determine the factors of the instrument, exploratory factor analysis with Varimax rotation was applied. It has been proved that among methods of rotation, Varimax is more robust and reliable (Hair, Anderson, Tatham, & Black, 1990). The results show seven factors (see Table 1 below).

**Table 1.**

Total Variance Explained

| Component | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 3.851 | 21.392 | 21.392 | 3.666 | 20.366 | 20.366 |
| 2 | 3.265 | 18.139 | 39.531 | 2.724 | 15.131 | 35.497 |
| 3 | 2.216 | 12.309 | 51.840 | 1.851 | 10.282 | 45.779 |
| 4 | 1.704 | 9.466 | 61.306 | 1.795 | 9.970 | 55.749 |
| 5 | 1.322 | 7.342 | 68.649 | 1.651 | 9.170 | 64.919 |
| 6 | 1.198 | 6.655 | 75.304 | 1.510 | 8.390 | 73.309 |
| 7 | 1.127 | 6.259 | 81.562 | 1.486 | 8.253 | 81.562 |

Extraction Method: Principal Component Analysis.

The table presents the Eigen values, variance and cumulative variance, sum of squares of the loading, before and after the rotation, of the components. Since the variables of the first factor are more than other factors, the highest Eigen value relates to the first factor. As it can be seen in Table 1, seven factors with Eigen values higher than 1 are produced. It should be noted, however, that Eigen value is not sufficient for factor determination. Therefore, the variance that can be accounted for by each factor and the Scree plot are needed (see Figure 1). It should be stated that the seven factors, before rotation, could account for 21.392, 18.139, 12.309, 9.466, 7.342, 6.665 and 6.25, percent of the variance, respectively. As it can be visualized in the slope of the Scree plot below, seven factors are identified. Based on the findings of the preliminary factor analysis, it was decided to extract seven factors through Varimax rotation, which produces independent factors. The findings are displayed in Table 1, Table 2 and Table 3.

Table 2 displays the factor loadings of the variables (trials) before the rotation. As it can be seen, four variables converge on one factor and their loadings are considerably high while following factor 1, bipolar factors appear which have positive and negative loadings that make the interpretation of the factors complicated. Hence rotation is necessary. The results of Varimax rotation are presented in Table 1.

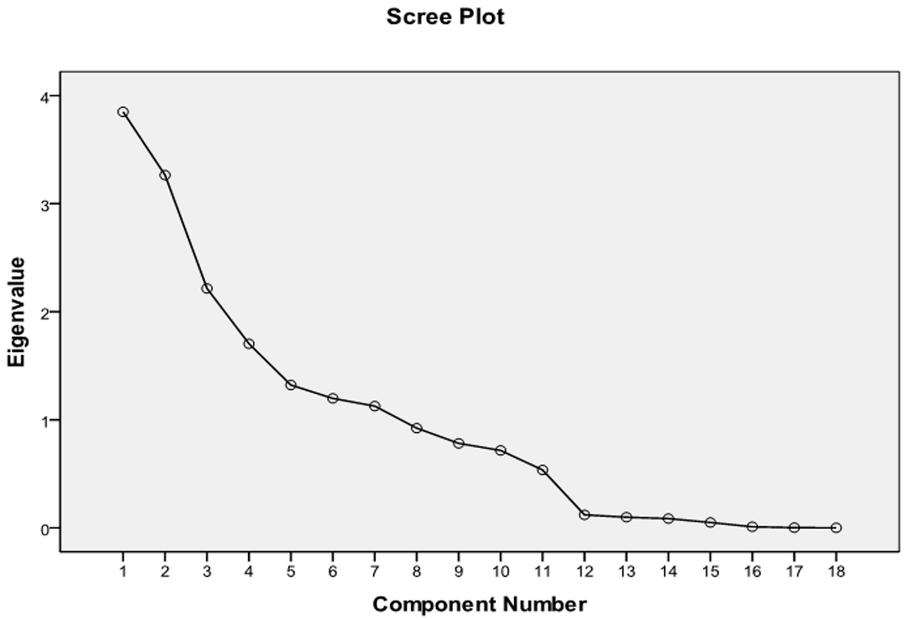


**Figure 1.**

Scree Plot of Component Number

**Table 2.**

Rotated Component Matrix[a]

| | Component | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| M3T | .966 | -.054 | -.026 | .008 | .044 | .041 | -.094 |
| M2T | .962 | -.047 | .059 | -.043 | .030 | -.010 | -.091 |
| M3N | -.942 | .107 | .009 | -.022 | -.092 | -.073 | -.157 |
| M2N | -.910 | -.085 | -.015 | .032 | .144 | .049 | -.200 |
| R2F | .028 | .799 | -.159 | .149 | -.150 | .146 | -.187 |
| L2T | .140 | -.653 | -.360 | -.107 | -.297 | .347 | -.113 |
| R3T | .071 | -.636 | -.127 | .402 | .046 | -.025 | -.258 |
| R2N | .023 | -.166 | .951 | -.144 | .022 | -.100 | .119 |
| R2T | -.057 | -.488 | -.778 | .020 | .101 | -.021 | .045 |
| R3N | -.003 | .171 | .117 | -.965 | .008 | -.056 | .074 |
| R3F | -.055 | .392 | -.011 | .752 | -.037 | .071 | .151 |
| L3N | -.004 | .090 | .032 | .023 | .927 | -.059 | .156 |
| L3F | -.131 | .483 | .198 | .168 | -.643 | .005 | .254 |
| L2N | -.087 | .319 | .262 | -.049 | .238 | -.813 | .049 |
| L2F | -.035 | .355 | .110 | .091 | .127 | .807 | .090 |
| M3F | .061 | -.166 | .049 | .044 | .151 | .103 | .744 |
| M2F | .147 | .320 | -.020 | -.117 | -.252 | -.121 | .632 |
| L3T | .093 | -.426 | -.168 | -.152 | -.251 | .003 | -.437 |

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 11 iterations.

**Table 3.**

Reliability Statistics of Components

| Component | Cronbach's Alpha |
|---|---|
| target identification accuracy | .960 |
| location error | .573 |
| Two – second right error | .786 |
| Three-second right error | .775 |
| Three-second left error | .665 |
| Two – second left error | .563 |
| Total | 0.650 |

As it can be seen in Table 2, Eigen values of factors before the rotation are 3.851, 3.265, 2.216, 1.704, 1, 322, 1.198 and 1.127, respectively while after the rotation the Eigen values are 3.666, 2.724, 1.851, 1.795, 1.651, 1.510, and 1.486, respectively.

The results of Varimax rotation showed that M3T, M2T, M3N, M2N having loadings of more than .91 belong to the first factor named 'target identification accuracy' whose reliability turned out to be α =.96. Factor loadings of R2F, L2T, and R2N were .63. These variables constitute the 'location error' factor the reliability of which is α= .57. Factor loadings of R2N & R2T amount to .77. These variables make up the 'Two – second right error' factor. The reliability of this factor was estimated to be α=.78. Factor loadings of R2T and R2N were more than .77. These variables constitute the 'Three-second right error' factor the reliability of which is .77. Factor loadings of L3n and L3F were more than .64. These variables make up the 'Three-second left error' factor. The reliability of this factor turned out to be α=.66. Factor loadings of L2N and L2F were more than .8. These variables constitute the 'Two – second left error' factor the reliability of which was α= .56. Factor loadings of M3F and M2F were more than .63. These variables make up the 'Target identification error' factor. The reliability of this factor turned out to be α= .65.

As it can be seen in Table 3, the reliability of the test is .65. Moreover, the lowest reliability index is that of the 'Two – second left error' (α= .56) and the highest index relates to 'Target identification accuracy' factor (α= .96).

## Discussion

Demonstrating the reliability of a negative priming effect is a prerequisite for conducting such research. However, this information is hardly ever provided, this raises questions about the confidence one can place in the conclusions reached in these studies. The available literature on inhibition conceals a paradox. On the one hand, research on the negative priming effect stresses that the function of inhibition, as evidenced by negative priming is not to help interference resolution and that there is no consistent relationship between them. On the other hand, psychometric research that focuses on the role of inhibition as a mediator of aging, disregards negative priming measures and uses interference scores (Kwong See & Ryan, 1995; Salthouse & Meinz, 1995). The key to this paradox is reliability. In negative priming research, reliability is not a topic, whilst in psychometric research, it is.

As it was mentioned earlier, the purpose of the present study was to develop and validate a new measure for assessing the effect of Negative Priming in the performance of the working memory, the speed of information processing and selective attention in Iran. The effect of negative priming, in a combinatorial manner, on incidental retrieving, through time and place differentiation of the stimulus of the subjects was assessed. This was done in

one-trial target identification which was neutral and distracter-free and two different but simultaneous and chance incidence of the primary stimulus in right and left location with two and three seconds time interval.

To examine the validity of the test, exploratory factor analysis with principle axis factoring and Varimax rotation was utilized. In Factor Analysis because the number of the first factors is more than other factors, especially the highest, will be the first factor. But the only criterion used for the extraction of Eigen values greater than one factor is very misleading, because so many factors to be extracted by each factor and specially to chart the amount of variance. The Eigen values of the six factors, before rotation, were 3.851, 3.265, 2.216, 1.704, 1.322 and 1.198, respectively while the values after rotation turned out to be 3.666, 2.724, 1.851, 1.795, 1.651 and 1.510, respectively. The final decision about the number of extracted factors, the Scree plot of component number was considered. The cut-off point for the rotation is where the slope changes. The numbers of factors for rotation using this method as the amount of variance were 6 factors. The extracted factors were: target identification accuracy, location error, two – second right error, three-second right error, three-second left error and two – second left error. The Cronbach's Alpha reliability of each factor were .96, .57, .78, .77, .66, .56, respectively and the reliability of the whole test turned out to be .65. Also the results of Pearson Correlation for concurrent validity between NP components and PVSAT tests were directly significant relation with correct answers (0.24 - and 0.42,$P \leq 0.05$) and was inversely and significantly (-0.37 - and -0.24,$P \leq 0.05$) . So the new test has concurrent validity with PVSAT.

Since tests for assessing mental disorders are scarce in Iran, developing a new measure would be very helpful. This test can simultaneously assess a multiplicity of cognitive performance in different age groups. In most existing tests, the individuals face a distractor while the present test makes the individuals think of three things and react to them simultaneously. Nerve psychology data and studies on individual differences show that identifying and locating an object are processed via two inhibition systems (May et al., 1995).

As to the reliability and validity of such tests, no study is reported in Iran. In other countries, however, some studies have been done with tests of brain performance with negative priming. Nonetheless, the validity and reliability of these instruments seem problematic. Having done empirical studies, Kane et al. (1997) reported the inadequacies of reliability and validity of tests of memory with inhibiting stimuli. Moreover, Bestgen and Dupont (2000) failed to achieve satisfactory reliability of three measures of the effect of inhibiting stimuli on working memory. These measures, to be named, are retrieval model, locating model and Norton's Paradigm. In a study on symbolic and non-symbolic coding to assess the effect of negative priming on the working memory, found that only non-symbolic coding measure was reliable.

Tests of the effect of negative priming on cognitive performance relate to individual differences, particularly the age. The present study done with two-second interval between trials showed no significant difference between the young and the adult subjects, while in target identification (distracter-free) there is significant difference between age groups. The results, here, are in line with the study of Little and Hartley (2000) on the effect of negative priming on the memory of different age groups. In a study with Stroop color-word tasks, they found no significant difference between young and adult subjects. Kieley and Hartley (1997) also found that negative priming and inhibiting stimuli affected adults, due to the effect of selective attention, more than youngsters. For example, three studies on word retrieval tests showed that target identification more than negative priming inhibits the adults. Gamboz and Russo (2002) have reported similar findings.

Osorio, Fay, Pouthas, & Ballesteros (2010) reported the negative effect of negative priming in reaction and cognitive performance of different age groups. However, they showed that adults had a better performance on exhibited robust priming and addition frontal activity was observed.

In a meta-analysis on individual differences of age in tests of the effect of negative priming on working memory (Twenty one studies on retrieval and eight on locating objects), Verhaeghen and De Meersman (1998) claimed that negative priming is significant with all age groups. The effect of age on the repetition of primary stimulus and the effect of individual differences in intentional learning and working memory have been studied by Lawson, Guo, and Jiang (2007). The effect of primary repetition as a priori and posteriori inhibiting factor was carried out with young subjects. The results showed that posterior effect is not influenced by intentional learning. Moreover, adult subjects unlike young subjects exhibited the value of communication model more than the value of time model in the interference of negative priming, that is, adults are careful with the relationship between primary and secondary stimuli. McLaughlin et al. (2010) observed that the role of age in different measures of assessing the performance of working memory and the effect of interference and inhibiting factors.

Following the development and validation of the present measure, it can be used in clinics with people who suffer disorders in concentration, focus level, working and short memory and speed of information processing. It can also be used for research purposes but it is important that one does not over-generalize the conclusions to all measures of negative priming in all conditions and with every type of participant.

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