

The modified Hayling Test: Details and Instructions

Background to the standard Hayling Test

The standard Hayling Test was developed to capture cognitive impairment after damage to the frontal lobes (Burgess & Shallice, 1996, 1997). There are two parts, part A involving initiation of verbal responses, and part B involving suppression of verbal responses. Neuropsychologists have been particularly interested in part B as a measure of response suppression or inhibition. Indeed, several neuropsychological studies have confirmed that the test is sensitive to frontal damage, and further suggested that integrity of the right frontal lobe is essential for successful suppression, i.e. part B performance (Robinson et al., 2015, Roca et al., 2009, Volle et al., 2011, Cipolloti et al., 2016). In fact, Hayling part B performance is one of the most clearly lateralized executive function tests.

More recently, studies have shown that the Hayling Test, particularly part B, can be used in healthy adults to measure normal variation in verbal suppression ability (Pluck et al., 2016, Pluck et al., 2019, Pluck et al., in press) and may have a special association with successful behaviour in challenging environments, validating it's a real-life role in top-down cognitive control. Hayling Test part B performance is also impaired following frontal lobe damage independently to changes in general intelligence (Roca et al., 2009) and performance in part B performance is not correlated with IQ (Pluck et al., 2016). This suggests that unlike most executive function tests, Hayling part B measures a relatively pure executive function (most 'executive' tests are likely measure general intelligence to a large extent).

The basic Hayling Test is administered as 15 trials in part A (initiation) and the 15 trials in part B (suppression). In both parts the experimenter reads aloud sentences in which the final word is missing, and the participants task is to complete the sentence. In part A the instruction is to complete the sentence with a sensible word that completes the sentence well. In contrast, for part B the participant is told to complete the sentence with a word that makes no sense. Therefore, in part B, the participant must suppress the tendency to complete sentences with sensible words, and to generate a nonsense response. Good performance, i.e. ability to suppress sensible-completion words and to generate nonsense words seems to require top-down cognitive control.

However, there are some problems with how the Hayling test is administered which make it difficult to interpret the processes underling performance. This is because of the blocked administration, all part A trials, and then all part B trials. This allows participants to use strategies, such as naming objects in vision, and potentially holding responses in working memory read for use later (holding the word 'mushroom' will most probably be a good, i.e. nonsense, response to any sentence in part B). The use of strategies in performance has been confirmed by Burgess & Shallice (1996) and Robinson et al., (2015).

The modified Hayling Test

The modified Hayling Test was developed to make it harder for participants to use such strategies. The modified version is also more challenging and may be more appropriate for use with healthy participants (the standard Hayling test suffers from floor effects in non-clinical groups). The modified Hayling interferes with strategy use because of three changes to the administration.

- i) The blocked aspect is removed, part A (initiation) and part B (suppression) trials are presented randomly so that the participant doesn't know which is coming next.
- ii) The participant is asked to read aloud the whole sentence, this makes it more difficult to hold responses in working memory (in the standard Hayling test the experimenter reads the sentences).
- iii) There is an embedded working memory span task: the participant has to store single words over the short term, while simultaneously performing the sentence reading, and the initiation / suppression of responses. This also makes it difficult to prepare and hold responses in advance.

These changes do indeed make the Hayling suppression performance more difficult and result in significantly longer suppression times and significantly higher errors scores, compared to the standard Hayling part B (Pluck et al., 2019). A further benefit of the modified Hayling Test is that in addition to the initiation and suppression scores (RT and accuracy), you also get a working memory span task score. The modified Hayling test described in Pluck et al., (2019) is available to download from www.gpluck.co.uk. That research was conducted with a Spanish-speaking group, and so the materials are in Spanish. However, it would be relatively simple to edit the PowerPoint file and scoring page. To make an English, or other language version, simply change the Spanish sentences for those from a Hayling test in the desired language. In fact, the modified Hayling Test described here is made with the 30 sentences in a Spanish standard Hayling Test used for research in Cuba (Obeso, et al., 2011).

Those 30 sentences, 15 from part A and 15 from part B, were put into a PowerPoint file. Nine were used for initiation trials, 14 for suppression trials and 7 for working memory trials. They were mixed pseudo-randomly. The experiment is run by showing the PowerPoint file in presentation mode, with the experimenter controlling the advancement of the slides. For each trial, the participant is presented with the sentence that lacks the final word. As the participant reads the final word on screen the experimenter advances the next slide, which gives the cue to the participant of how to react.

- If they are simply given the word that completes the sentence (shown in purple on the screen), their task is to hold it in memory.
- If they are given a green check (tick) mark and a chime sound, they should make an initiation response, i.e. complete the sentence with a sensible word (equivalent to part A performance).
- If they are presented with a red cross mark and a beep, then they should suppress the prepotent response and complete the sentence with a word that makes no sense in the context of the sentence (equivalent to part B performance).
- Some trials simply show question marks '????????'. That means that the participant should recall the word they had previously tried to hold in memory.

The experimenter then advances to the next trial by pressing the space bar.

Unlike the standard Hayling Test, for the modified version the whole performance should be audio recorded and scored later. This allows better control of the measuring of RTs. The information can be transcribed onto the data page at the end of this document. The response time is measured from the time of the prompt (the chime for initiation or the beep for suppression) until the participant starts to say the word. This should be done with a stopwatch, and recorded as seconds to one decimal place. The actual word uttered should be written down for later scoring of accuracy.

For initiation trails errors are rare and so the variable of most interest is initiation RT. For suppression trails, RT is of interest, but accuracy is also evaluated. The scoring for accuracy is exactly as is done with the standard Hayling test. This is an error score, so higher scores indicate worse performance.

- Category A scores (0 points) are given if the word makes no sense in the context.
- Category B scores (1 point) are words that are semantically related to the sentence
- Category C scores (3 points) are words that sensibly complete the sentence i.e. they are words that would be expected based on the sentence context.

The total suppression error score is the sum of the error scores from the 14 suppression trials. Scoring individual trails can be difficult and users of the test should consult Burgess and Shallice (1996) and Robinson et al., (2015) for further guidance. In the educational research in which the modified Hayling was developed we also scored for strategy use, which can also be coded based on the details in Burgess and Shallice (1996) and Robinson et al., (2015). The working memory score is simply the total number of trials when the word was recalled (in each memory trial the participant is required to recall only the previous word shown in purple, if they do, they receive one point for that trial).

Further details of the modified Hayling Test, concerning its construction and administration can be found in Pluck et al. (2019). To contact me for further information, use the form on my website: www.gpluck.co.uk.

If you use the modified Hayling Test in any thesis or published research please cite the method to:

Pluck, G., Villagomez-Pacheco, D., Karolys, M. I., Montaña-Córdova, M. E. & Almeida-Meza, P. (2019). Response suppression, strategy application, and working memory in the prediction of academic performance and classroom misbehavior: A neuropsychological approach. *Trends in Neuroscience and Education*, 17, 100121. <https://doi.org/10.1016/j.tine.2019.100121>

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Dr Graham Pluck, Quito, 9th December 2019

Data Record Page

Complete the boxes in grey while listening to the recording. For *Response* write down the exact word(s). For *Time* give seconds, e.g. '3.4'. Responses can be scored later for accuracy

Phrase on screen	Task Type	Response	Time
1 Mandó una carta sin SELLO	Remember		
2 En el primer espacio escribe tú	Initiation		
3 La vieja casa va a ser	Suppression		
4 Es difícil de admitir cuando uno está	Suppression		
	Recall	Sello 0 / 1	N/A
5 El trabajo fue fácil la mayor parte del DIA	Remember		
6 Cuando te vayas a la cama apaga la	Initiation		
7 El partido se suspendió cuando empezó a	Suppression		
8 Se comió todo lo que le sirvieron en su	Initiation		
	Recall	Dia 0 / 1	N/A
9 La discusión fue resuelta por una tercera VEZ	Remember		
10 Tres peatones fueron atropellados en la	Suppression		
11 El bebe lloró y enfadó a su	Initiation		
12 Jorge no podría creer que su hijo robe una	Suppression		
13 Entró en la habitación sin hacer ningún	Suppression		
	Recall	Vez 0 / 1	N/A
14 Miguel pegó a su hermana en la CABEZA	Remember		
15 El niño cogió el pastel y se lo	Suppression		
1 El capitán debía permanecer el ultimo al hundirse el	Initiation		
2 Llegaron tan lejos como	Suppression		
	Recall	Cabeza 0 / 1	N/A
3 Los gatos ven muy bien por la NOCHE	Remember		
4 Juan está contento ya que su problema está	Suppression		
5 En la clausura del acto, el presidente dio un memorable	Suppression		
6 Los tiburones suelen atacar cerca de la	Initiation		
	Recall	Noche 0 / 1	N/A
7 Ese libro no me transmitió ninguna INFORMACIÓN	Remember		
8 Asaron el cerdo en el	Suppression		
9 Ella llamo al marido a su	Initiation		
10 Todos los invitados pasaron una fantástica	Suppression		
	Recall	Información 0 / 1	N/A
11 Compró los caramelos en la TIENDA	Remember		
12 Abandonó su casa dejando sorprendida a toda su	Initiation		
13 Al final, llego el momento de la	Initiation		
14 El perro persiguió que subió al	Suppression		
15 Por la noche ellos usualmente salen a	Suppression		
	Recall	Tienda 0 / 1	N/A