

University of Groningen

## Computer programming skills: A cognitive perspective

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DOI:  
[10.33612/diss.168003240](https://doi.org/10.33612/diss.168003240)

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*Document Version*  
Publisher's PDF, also known as Version of record

*Publication date:*  
2021

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Graafsma, I. (2021). *Computer programming skills: A cognitive perspective*. [Thesis fully internal (DIV), University of Groningen]. University of Groningen. <https://doi.org/10.33612/diss.168003240>

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## Appendix A

Table with item details that were used to split the SCS1 programming test into two versions

**Table A.1** Items assigned to SCS1-S1 with the level of difficulty as estimated according to the first validation of the SCS1 by Parker et al. (2016) and according to our pilot work.

Question number SCS1-S1	Original question from SCS1	Topic	Type of question	Difficulty according to Parker et al. (2016)	Difficulty according to our pilot study	Level of discrimination according to Parker et al. (2016)	Level of discrimination according to our pilot study
SCS1-S1							
1	1	for	definitional	moderate	.18	good	.13
2	2	logical operator	tracing	moderate	.41	good	.29**
3	5	function return values	tracing	hard	.12	poor	.14
4	6	if	definitional	hard	.46	fair	.31**
5	9	while	tracing	hard	.29	fair	.43***
6	12	basics	definitional	hard	.50	fair	.42***
7	13	for	code completion	hard	.16	fair	.18
8	14	recursion	definitional	hard	.35	good	.49***
9	17	arrays	code completion	hard	.23	fair	.50***
10	18	recursion	code completion	hard	.22	poor	.18
11	22	arrays	tracing	hard	.32	fair	.54***
12	25	basics	code completion	hard	.46	fair	.60***

13	27	function parameters	tracing	hard	.18	poor	.23
SCS1-S2							
1	3	while	definitional	moderate	.61	good	.39***
2	4	arrays	definitional	hard	.23	fair	.46***
3	7	while	code completion	hard	.23	fair	.52***
4	8	for	Tracing	hard	.33	poor	.37***
5	10	logical operator	definitional	hard	.45	fair	.33***
6	11	function return values	definitional	hard	.20	fair	.21*
7	16	function parameters	code completion	hard	.21	fair	.45***
8	19	if	tracing	moderate	.52	good	.58***
9	20	function parameters	definitional	hard	.16	poor	.24*
10	21	if	code completion	hard	.29	fair	.55***
11	23	basics	tracing	moderate	.57	fair	.62***
12	24	recursion	tracing	hard	.18	poor	.15
13	26	logical operator	code completion	hard	.28	fair	.39***

Note: Difficulty is defined as the proportion of correct attempts for each question. Discriminability is defined by the point biserial correlation between the score on each item and total SCS1-S score. Unanswered questions were counted as incorrect.



# Appendix B

Stimuli for the Event Related Potential experiment

## Experimental stimuli

### Dutch

#### *Grammatical*

##### **List 1**

Het heeft veel tijd nodig.  
Hij doet een goede zet.  
Hij is een slechte kok.  
Hij kon slecht vogels vangen.  
Ik doe dit nooit meer.  
Ik durf alleen te reizen.  
Ik kan de was doen.  
Ik was een geweldige docent.  
Jij bent een aardige jongen.  
Jij deed dat elke dag.  
Jij kunt niet goed duiken.  
Jullie doen heel belangrijk werk.  
Jullie durven wel te springen.  
Jullie hebben een lange vakantie.  
Wij durven morgen te protesteren.  
Wij hadden vroeger een paard.  
Wij hebben een mooi standbeeld.  
Wij konden goed huiswerk maken.  
Wij kunnen dat heel goed.  
Zij is een goede zwemster.

##### **List 2**

Het deed er niet toe.  
Het kan elk moment gebeuren.  
Hij durft alles te vragen.  
Hij heeft een gebroken been.  
Hij kan goed bloemen tekenen.  
Hij was een goede fotograaf.  
Ik ben een goede student.  
Ik heb veel mooie verhalen.  
Ik kan goed aardappels schillen.  
Jij doet altijd zo gek.  
Jij durft dit te bespreken.  
Jij hebt even pauze nodig.  
Jij hebt veel dure kleding.  
Jij kon heel goed rekenen.  
Jullie hadden veel films gemaakt.  
Jullie kunnen heel goed dansen.  
Jullie zijn een gezellige club.  
Wij deden het moeilijke examen.  
Wij doen ons werk dagelijks.  
Wij zijn een beetje moe.

**Ungrammatical****List 1**

Het deden er niet toe.  
 Het kunnen elk moment gebeuren.  
 Hij durven alles te vragen.  
 Hij hebben een gebroken been.  
 Hij kunt goed bloemen tekenen.  
 Hij waren een goede fotograaf.  
 Ik bent een goede student.  
 Ik hebben veel mooie verhalen.  
 Ik kunnen goed aardappels schillen.  
 Jij doe altijd zo gek.  
 Jij durven dit te bespreken.  
 Jij heeft even pauze nodig.  
 Jij heeft veel dure kleding.  
 Jij konden heel goed rekenen.  
 Jullie had veel films gemaakt.  
 Jullie is een gezellige club.  
 Jullie kan heel goed dansen.  
 Wij deed het moeilijke examen.  
 Wij doet ons werk dagelijks.  
 Wij is een beetje moe.

**List 2**

Het hebben veel tijd nodig.  
 Hij bent een slechte kok.  
 Hij doe een goede zet.  
 Hij konden slecht vogels vangen.  
 Ik doet dit nooit meer.  
 Ik durven alleen te reizen.  
 Ik kunt de was doen.  
 Ik waren een geweldige docent.  
 Jij deden dat elke dag.  
 Jij kunnen niet goed duiken.  
 Jij zijn een aardige jongen.  
 Jullie doet heel belangrijk werk.  
 Jullie durft wel te springen.  
 Jullie heeft een lange vakantie.  
 Wij durft morgen te protesteren.  
 Wij had vroeger een paard.  
 Wij heeft een mooi standbeeld.  
 Wij kan dat heel goed.  
 Wij kon goed huiswerk maken.  
 Zij ben een goede zwemster.



**English**

***Grammatical***

**List 1**

He is an expert programmer.  
He needs to practice drawing.  
He was a clever journalist.  
I am an excellent painter.  
I have many tasty snacks.  
I need some more potatoes.  
It dares to sneak inside.  
It needs to happen now.  
She dares to say anything.  
She does her stretches daily.  
She has a big nose.  
They have many famous books.  
They need a short break.  
They were always very mean.  
We are a bit late.  
We do the expensive groceries.  
You dare to present this.  
You do all the chores.  
You have so many shoes.  
You were a bad swimmer.

**List 2**

He dares to jump far.  
He does the dirty dishes.  
He has a rare disease.  
I dare to cycle fast.  
I do a silly dance.  
I was a terrible singer.  
It does that every day.  
It has a long tail.  
It is a bad choice.  
She is a great dancer.  
She needs a long holiday.  
They are a friendly group.  
They dare to climb high.  
They do their difficult task.  
We dare to fight them.  
We have a beautiful painting.  
We need a strong coffee.  
We were a great team.  
You are a good friend.  
You need to eat more.

***Ungrammatical*****List 1**

He dare to jump far.  
 He do the dirty dishes.  
 He have a rare disease.  
 I dares to cycle fast.  
 I does a silly dance.  
 I were a terrible singer.  
 It are a bad choice.  
 It do that every day.  
 It have a long tail.  
 She are a great dancer.  
 She need a long holiday.  
 They am a friendly group.  
 They dares to climb high.  
 They does their difficult task.  
 We dares to fight them.  
 We has a beautiful painting.  
 We needs a strong coffee.  
 We was a great team.  
 You is a good friend.  
 You needs to eat more.

**List 2**

He are an expert programmer.  
 He need to practice drawing.  
 He were a clever journalist.  
 I has many tasty snacks.  
 I is an excellent painter.  
 I needs some more potatoes.  
 It dare to sneak inside.  
 It need to happen now.  
 She dare to say anything.  
 She do her stretches daily.  
 She have a big nose.  
 They has many famous books.  
 They needs a short break.  
 They was always very mean.  
 We am a bit late.  
 We does the expensive groceries.  
 You dares to present this.  
 You does all the chores.  
 You has so many shoes.  
 You was a bad swimmer.

**Java**

***Grammatical***

**List 1**

if (a>=5)  
if (a>2)  
if (b!=1)  
if (b==40)  
if (i<7)  
if (j==110)  
if (x<=23)  
if (x<20)  
if (z!=14)  
if (z<32)  
while (a!=6)  
while (b==4)  
while (j>15)  
while (k>5)  
while (p==55)  
while (v<2)  
while (x<26)  
while (x==0)  
while (y<=6)  
while (z>37)

**List 2**

if (a<10)  
if (a==100)  
if (b<=107)  
if (b<22)  
if (i!=10)  
if (i==2)  
if (x<27)  
if (x>5)  
if (z!=0)  
if (z>=2)  
while (a==0)  
while (b!=4)  
while (b==10)  
while (i==7)  
while (i>1)  
while (j<20)  
while (j<22)  
while (k>=50)  
while (x<10)  
while (x>0)

**Ungrammatical****List 1**

if {a<10}  
if {a==100}  
if {b<=107}  
if {b<22}  
if {i!=10}  
if {i==2}  
if {x<27}  
if {x>5}  
if {z!=0}  
if {z>=2}  
while {a==0}  
while {b!=4}  
while {b==10}  
while {i==7}  
while {i>1}  
while {j<20}  
while {j<22}  
while {k>=50}  
while {x<10}  
while {x>0}

**List 2**

if {a>=5}  
if {a>2}  
if {b!=1}  
if {b==40}  
if {i<7}  
if {j==110}  
if {x<=23}  
if {x<20}  
if {z!=14}  
if {z<32}  
while {a!=6}  
while {b==4}  
while {j>15}  
while {k>5}  
while {p==55}  
while {v<2}  
while {x<26}  
while {x==0}  
while {y<=6}  
while {z>37}

## Fillers

### Dutch

#### *Grammatical*

##### **Lists 1 and 2**

Daar stroomt een grote rivier.

Dat is een officieel instituut.

Dat was een ernstig incident.

De afgekeurde manuscripten werden vernietigd.

De mooie etiketten worden verkocht.

De noodzakelijke vetten zijn gezond.

De turnster had een uitdaging.

De uitgebreide documenten worden besproken.

De verplichte formulieren liggen daar.

Er hing een zeldzame viool.

Er is een giftig gas.

Er ontstond een acute crisis.

Het huidige adres is onbekend.

Het ingewikkelde recept is lekker.

Het moderne concert klonk goed.

Het nieuwe paspoort is geldig.

Hij gebruikte een klassiek instrument.

Hij ontdekte een nieuw continent.

Hij verdiende een goed salaris.

Zij heeft een indrukwekkend fort.

***Ungrammatical***

**Lists 1 and 2**

Daar is een diepe meer.

Dat was een gevaarlijke park.

De lang touwen hangen daar.

De leeg nesten waren verspreid.

De radicaal fronten bevochten elkaar.

Er is een nieuw klok.

Er ligt een ongebruikte apparaat.

Er stond een hoge hek.

Het beschadigde netten werden vervangen.

Het bot mes werkt niet.

Het donkere vlakken moeten gewit.

Het moeilijke vakken werden gehaat.

Het piepende wielen werden gesmeerd.

Het was een grote avontuur.

Hier is een lange lint.

Hij gaf een grote compliment.

Hij heeft een sterk zoon.

Hij verliet een prachtige dorp.

Zij bezochten een prachtige plein.

Zij sloten een geheime pact.

**English**

***Grammatical***

**List 1 and 2**

Everyone likes to receive pay.

He loved magic a lot.

He played with the sand.

His dad earns some money.

I can't follow the logic.

I have so much homework.

I should gather my courage.

I was quickly granted permission.

It is a simple question.

It must have been tourism.

It's relatively easy to win.

Plants don't stop producing oxygen.

She handled most financial tasks.

She has a strong faith.

She has knowledge of health.

She never drinks enough water.

The hotel offered cheap transportation.

The professor discussed some research.

There was not much evidence.

We don't rely on agriculture.

***Ungrammatical***

**List 1 and 2**

A good health is important.

He didn't make a progress.

His leader demanded a progress.

I have never played hockeys.

I ran a finance today.

I will offer an advice.

I've access to an information.

My laptop generates a heats.

She packed all the luggages.

She really values a privacy.

She shows a good participation.

That is an important knowledge.

That was very much funs.

The car had a damage.

The greeds is not good.

The informations are not correct.

The team made many progresses.

The weathers have been terrible.

They perform maintenances on roads.

They stood on some gravels.



## Appendix B

### Java

#### *Grammatical*

##### **List 1 and 2**

```
else {j=i}
while (z==b)
if (b>=-5)
else {x=z}
else {x=2}
else {i=j}
while (y!=x)
else {j=100}
while (x<i)
else {v=-5}
else {v=0}
if (t==x)
else {y=1}
if (a==x)
else {i=0}
else {j=28}
else {v=1}
else {a=b}
else {x=10}
else {y=13}
```

***Ungrammatical*****List 1 and 2**

else (i=x)

else (v=100)

else (x==y)

else (x=0)

else (z==5)

else (z=y)

else {i>=14}

else {j== -10}

else {v<5}

else {x>z}

if (a=2)

if (b=-1)

if (j>>3)

if (x=40)

if (y<10)

while (i=1)

while (x<>6)

while (y=-10)

while (z<<0)

while (z>=<<23)



## Appendix C

Tables with all ANOVA and post hoc *t*-test results

**Table C.1.** Results of repeated measures ANOVAs for Dutch language stimuli.

Time window	200-400	400-600	600-800	800-1000
Lateral regions				
Grammaticality	$F(11) = 10.591, p = .008^{**}, \eta^2 G = .038$	$F(11) = 3.641, p = .083, \eta^2 G = .039$	$F(11) = 15.198, p = .002^{**}, \eta^2 G = .208$	$F(11) = 6.304, p = .029^{*}, \eta^2 G = .051$
Grammaticality*anteriority	$F(22) = .517, p = .511, \eta^2 G = .002$	$F(22) = 12.076, p < .001^{***}, \eta^2 G = .048$	$F(22) = 10.883, p < .001^{***}, \eta^2 G = .026$	$F(22) = 6.452, p = .006^{**}, \eta^2 G = .018$
Grammaticality*hemisphere	$F(11) = 0.049, p = .829, \eta^2 G < .001$	$F(11) = 3.631, p = .083, \eta^2 G = .014$	$F(11) = 1.483, p = .249, \eta^2 G = .006$	$F(11) = .443, p = 520, \eta^2 G = .001$
Midline regions				
Grammaticality	$F(11) = 4.648, p = .054, \eta^2 G = .040$	$F(11) = 2.133, p = .172, \eta^2 G = .049$	$F(11) = 9.972, p = .009^{**}, \eta^2 G = .281$	$F(11) = 8.228, p = .015^{*}, \eta^2 G = .137$
Grammaticality*anteriority	$F(22) = 0.586, p = .472, \eta^2 G = .003$	$F(22) = 8.079, p = .013^{*}, \eta^2 G = .040$	$F(22) = 2.581, p = .134, \eta^2 G = .013$	$F(22) = 8.656, p = .009^{**}, \eta^2 G = .025$

*Note:* The top part of the table shows the results for the ANOVAs with the lateral regions of interest and had grammaticality (2 levels: grammatical and ungrammatical), hemisphere (2 levels: left and right hemisphere), and anteriority (3 levels: anterior, central, and posterior) as between subject factors. The second part of the table shows the repeated measures ANOVAs only looked at the regions of interest in the midline and had grammaticality (2 levels: grammatical and ungrammatical), and anteriority (3 levels: anterior, central, and posterior). ANOVAs were run per 200ms time increment from 200-1000ms. As an effect size statistic for the ANOVA analyses, we report generalised eta squared ( $\eta^2 G$ ). \* indicates  $p$ -value below .05, \*\* indicates  $p$ -value below .01, \*\*\* indicates  $p$ -value below .001.

**Table C.2.** Results of post hoc *t*-tests for the interaction between grammaticality and anteriority and grammaticality and hemisphere for the Dutch language stimuli.

Time window	200-400ms	400-600ms	600-800ms	800-1000ms
	Lateral regions			
Grammaticality * Anteriority				
LA	X	$t(11) = -3.400, p = .006^{**}$	$t(11) = -5.287, p < .001^{***}$	$t(11) = -0.801, p = .440$
LC	X	$t(11) = -1.837, p = .093$	$t(11) = -3.842, p = .003^{**}$	$t(11) = -2.498, p = .030^*$
LP	X	$t(11) = 0.065, p = .949$	$t(11) = -1.647, p = .128$	$t(11) = -3.112, p = .010^{**}$
RA	X	$t(11) = -1.507, p = .160$	$t(11) = -3.833, p = .003^{**}$	$t(11) = 0.399, p = .698$
RC	X	$t(11) = -1.091, p = .299$	$t(11) = -3.174, p = .009^{**}$	$t(11) = -1.956, p = .076$
RP	X	$t(11) = 1.042, p = .320$	$t(11) = -1.850, p = .091$	$t(11) = -4.099, p = .002^{***}$
Grammaticality * Hemisphere				
Left	X	$t(11) = -2.239, p = .047^*$	X	X
Right	X	$t(11) = -2.147, p = .055$	X	X
	Midline regions			
Grammaticality * Anteriority				
MA	X	$t(11) = -2.851, p = .016^*$	X	$t(11) = -1.043, p = .320$
MC	X	$t(11) = -1.202, p = .255$	X	$t(11) = -3.022, p = .012^*$
MP	X	$t(11) = 0.014, p = .989$	X	$t(11) = -4.779, p < .001^{***}$

Note: Post hoc *t*-tests were only performed for time windows where an interaction was found between grammaticality and anteriority or grammaticality and hemisphere. \* indicates *p*-value below .05, \*\* indicates *p*-value below .01, \*\*\* indicates *p*-value below .001.

**Table C.3.** Results of repeated measures ANOVAs for English language stimuli.

Time window	200-400	400-600	600-800	800-1000
	Lateral regions			
Grammaticality	$F(11) = 0.274, p = .6112, \eta^2G = .002$	$F(11) = 0.390, p = .545, \eta^2G = .005$	$F(11) = 11.341, p = .006^{**}, \eta^2G = .188$	$F(11) = 5.535, p = .038^*, \eta^2G = .079$
Grammaticality*anteriority	$F(22) = 0.500, p = .523, \eta^2G = .002$	$F(22) = 0.620, p = .472, \eta^2G = .003$	$F(22) = 0.341, p = .579, \eta^2G = .002$	$F(22) = 12.735, p = .002^{**}, \eta^2G = .063$
Grammaticality*hemisphere	$F(11) = 0.091, p = .768, \eta^2G < .001$	$F(11) = 3.974, p = .072, \eta^2G = .011$	$F(11) = 3.036, p = .109, \eta^2G = .016$	$F(11) = 0.215, p = .652, \eta^2G = .279$
	Midline regions			
Grammaticality	$F(11) = 0.003, p = .955, \eta^2G < .001$	$F(11) = 0.353, p = .564, \eta^2G = .007$	$F(11) = 13.342, p = .004^{**}, \eta^2G = .296$	$F(11) = 10.428, p = .008^{**}, \eta^2G = .205$
Grammaticality*anteriority	$F(22) = 0.916, p = .373, \eta^2G = .005$	$F(22) = 0.730, p = .425, \eta^2G = .007$	$F(22) = 0.715, p = .428, \eta^2G = .005$	$F(22) = 13.739, p = .002^{**}, \eta^2G = .090$

*Note:* The top part of the table shows the results for the ANOVAs with the lateral regions of interest and had grammaticality (2 levels: grammatical and ungrammatical), hemisphere (2 levels: left and right hemisphere), and anteriority (3 levels: anterior, central, and posterior) as between subject factors. The second part of the table shows the repeated measures ANOVAs only looked at the regions of interest on the midline and had grammaticality (2 levels: grammatical and ungrammatical), and anteriority (3 levels: anterior, central, and posterior). ANOVAs were run per 200ms time increment from 200-1000 ms. As an effect size statistic for the ANOVA analyses, we report generalised eta squared ( $\eta^2G$ ). \* indicates  $p$ -value below .05, \*\* indicates  $p$ -value below .01, \*\*\* indicates  $p$ -value below .001.

**Table C.4.** Results of post hoc *t*-tests for the interaction between grammaticality and anteriority and grammaticality and hemisphere for the English language stimuli.

Time window	200-400ms	400-600ms	600-800ms	800-1000ms
	Lateral			
Grammaticality * Anteriority				
LA	X	X	X	$t(11) = -0.516, p = .616$
LC	X	X	X	$t(11) = -2.022, p = .068$
LP	X	X	X	$t(11) = -4.409, p = .001^{***}$
RA	X	X	X	$t(11) = 0.842, p = .418$
RC	X	X	X	$t(11) = -1.917, p = .082$
RP	X	X	X	$t(11) = -4.339, p = .002^{***}$
Grammaticality * Hemisphere				
Left	X	$t(11) = -2.507, p = .029^*$	X	X
Right	X	$t(11) = -1.635, p = .130$	X	X
	Midline			
Grammaticality * Anteriority				
MA	X	X	X	$t(11) = -0.407, p = .692$
MC	X	X	X	$t(11) = -3.585, p = .004^{***}$
MP	X	X	X	$t(11) = -5.249, p < .001^{***}$

Note: Post hoc *t*-tests were only performed for time windows where an interaction was found between grammaticality and anteriority or grammaticality and hemisphere. \* indicates *p*-value below .05, \*\* indicates *p*-value below .01, \*\*\* indicates *p*-value below .001.



**Table C.5.** Results of repeated measures ANOVAs for Java programming language stimuli.

Time window	200-400	400-600	600-800	800-1000
Lateral regions				
Grammaticality	$F(11) = 5.444, p = .040^*, \eta^2G = .050$	$F(11) = 15.200, p = .002^{**}, \eta^2G = .140$	$F(11) = 4.327, p = .062, \eta^2G = .052$	$F(11) = .191, p = .671, \eta^2G = .003$
Grammaticality*anteriority	$F(22) = .595, p = .471, \eta^2G = .003$	$F(22) = 3.478, p = .078, \eta^2G = .019$	$F(22) = 1.287, p = .286, \eta^2G = .008$	$F(22) = 1.164, p = .314, \eta^2G = .009$
Grammaticality*hemisphere	$F(11) = .438, p = .522, \eta^2G = .001$	$F(11) < .001, p = .989, \eta^2G < .001$	$F(11) = 1.264, p = .285, \eta^2G = .002$	$F(11) = .166, p = .692, \eta^2G = .001$
Midline regions				
Grammaticality	$F(11) = 3.519, p = .087, \eta^2G = .059$	$F(11) = 10.890, p = .007^{**}, \eta^2G = .184$	$F(11) = 2.601, p = .135, \eta^2G = .053$	$F(11) = .070, p = .796, \eta^2G = .002$
Grammaticality*anteriority	$F(22) = 1.282, p = .292, \eta^2G = .003$	$F(22) = 14.160, p = .001^{**}, \eta^2G = .037$	$F(22) = 6.224, p = .007^{**}, \eta^2G = .015$	$F(22) = 3.577, p = .074, \eta^2G = .024$

Note: The top part of the table shows the results for the ANOVAs with the lateral regions of interest and had grammaticality (2 levels: grammatical and ungrammatical), hemisphere (2 levels: left and right hemisphere), and anteriority (3 levels: anterior, central, and posterior) as between subject factors. The

second part of the table shows the repeated measures ANOVAs only looked at the regions of interest on the midline and had grammaticality (2 levels: grammatical and ungrammatical), and anteriority (3 levels: anterior, central, and posterior). ANOVAs were run per 200ms time increment from 200-1000

ms. As an effect size statistic for the ANOVA analyses, we report generalised eta squared ( $\eta^2G$ ). \*indicates  $p$ -value below .05, \*\* indicates  $p$ -value below .01, \*\*\* indicates  $p$ -value below .001.

**Table C.7.** Results of post hoc *t*-tests for the interaction between grammaticality and anteriority and grammaticality and hemisphere for the Java programming language stimuli.

Time window	200-400ms	400-600ms	600-800ms	800-1000ms
	Lateral			
Grammaticality * Anteriority				
LA	X	$t(11) = -4.548, p < .001^{***}$	X	X
LC	X	$t(11) = -2.985, p = .012^*$	X	X
LP	X	$t(11) = -1.413, p = .186$	X	X
RA	X	$t(11) = -3.218, p = .008^{**}$	X	X
RC	X	$t(11) = -3.842, p = .003^{**}$	X	X
RP	X	$t(11) = -1.667, p = .124$	X	X
Grammaticality * Hemisphere				
Left	X	X	X	X
Right	X	X	X	X
	Midline			
Grammaticality * Anteriority				
MA	X	$t(11) = -4.089, p = .002^{**}$	$t(11) = -2.915, p = .014^*$	$t(11) = -1.292, p = .223$
MC	X	$t(11) = -2.636, p = .023^*$	$t(11) = -1.300, p = .220$	$t(11) = 0.378, p = .713$
MP	X	$t(11) = -2.441, p = .033^*$	$t(11) = -0.613, p = .553$	$t(11) = 1.014, p = .333$

Note: Post hoc *t*-tests were only performed for time windows where an interaction was found between grammaticality and anteriority or grammaticality and hemisphere. \* indicates *p*-value below .05, \*\* indicates *p*-value below .01, \*\*\* indicates *p*-value below .001.

**Table C.8.** Results of repeated measures ANOVAs with the difference scores between the grammatical and ungrammatical stimuli for each language.

Time window	200-400	400-600	600-800	800-1000
	Lateral regions			
Language	$F(22) = 1.227, p = .312, \eta^2G = .039$	$F(22) = 5.820, p = .009^{**}, \eta^2G = .146$	$F(22) = 2.719, p = .088, \eta^2G = .055$	$F(22) = 1.564, p = .232, \eta^2G = .044$
Language*anteriority	$F(44) = 1.016, p = .380, \eta^2G = .014$	$F(44) = 4.716, p = .020^*, \eta^2G = .055$	$F(44) = 4.420, p = .004^{**}, \eta^2G = .025$	$F(44) = 6.400, p = .005^{**}, \eta^2G = .069$
Language*hemisphere	$F(22) = .098, p = .907, \eta^2G = .001$	$F(22) = 1.450, p = .256, \eta^2G = .012$	$F(22) = 2.308, p = .123, \eta^2G = .018$	$F(22) = .254, p = .778, \eta^2G = .004$
	Midline regions			
Language	$F(22) = 1.270, p = .301, \eta^2G = .062$	$F(22) = 3.098, p = .065, \eta^2G = .088$	$F(22) = 2.736, p = .087, \eta^2G = .076$	$F(22) = 4.331, p = .026^*, \eta^2G = .162$
Language*anteriority	$F(44) = 1.419, p = .262, \eta^2G = .018$	$F(44) = 6.017, p = .017^*, \eta^2G = .054$	$F(44) = 4.816, p = .012^*, \eta^2G = .020$	$F(44) = 10.180, p < .001^{***}, \eta^2G = .101$

*Note:* The top part of the table shows the results for the ANOVAs with the lateral regions of interest and had language (3 levels: Dutch, English and Java), hemisphere (2 levels: left and right hemisphere), and anteriority (3 levels: anterior, central, and posterior) as between subject factors. The second part of the table shows the repeated measures ANOVAs only looked at the regions of interest on the midline and had language (3 levels: Dutch, English and Java), and anteriority (3 levels: anterior, central, and posterior). ANOVAs were run per 200ms time increment from 200-1000 ms. As an effect size statistic for the ANOVA analyses, we report generalised eta squared ( $\eta^2G$ ). \*indicates  $p$ -value below .05, \*\* indicates  $p$ -value below .01, \*\*\* indicates  $p$ -value below .001.

**Table C.9.** Results of post hoc *t*-tests for the main effects of language, the interactions between language and anteriority and language and hemisphere for the difference scores between grammatical and ungrammatical stimuli for each language.

Time window	200-400ms	400-600ms	600-800ms	800-1000ms	
Lateral					
Main					
	Dutch vs Java	X	$t(71) = -2.896, p = .015^*$	$t(71) = 4.002, p < .001^{***}$	X
	English vs Java	X	$t(71) = -5.637, p < .001^{***}$	$t(71) = 2.853, p = .018^*$	X
	Dutch vs English	X	$t(71) = 3.301, p = .005^{**}$	$t(71) = .738, p = .999$	X
Grammaticality * Anteriority					
LA	Dutch vs Java	X	$t(11) = -.221, p = .999$	$t(11) = 2.873, p = .045^*$	$t(11) = 0.232, p = .999$
	English vs Java	X	$t(11) = -2.131, p = .170$	$t(11) = 1.901, p = .251$	$t(11) = -0.083, p = .999$
	Dutch vs English	X	$t(11) = 2.209, p = .150$	$t(11) = 0.922, p = .999$	$t(11) = 0.346, p = .999$
RA	Dutch vs Java	X	$t(11) = -1.084, p = .904$	$t(11) = 1.503, p = .480$	$t(11) = -0.997, p = .999$
	English vs Java	X	$t(11) = -3.316, p = .021^*$	$t(11) = -0.756, p = .999$	$t(11) = -1.102, p = .880$
	Dutch vs English	X	$t(11) = 3.274, p = .022^*$	$t(11) = 2.407, p = .100$	$t(11) = 0.565, p = .999$
LC	Dutch vs Java	X	$t(11) = -0.844, p = .999$	$t(11) = 2.344, p = .120$	$t(11) = 2.034, p = .200$
	English vs Java	X	$t(11) = -2.823, p = .050$	$t(11) = 2.077, p = .190$	$t(11) = 1.531, p = .460$
	Dutch vs English	X	$t(11) = 1.467, p = .510$	$t(11) = 0.460, p = .999$	$t(11) = 0.633, p = .999$
RC	Dutch vs Java	X	$t(11) = -3.580, p = .013^*$	$t(11) = 0.978, p = .999$	$t(11) = 0.768, p = .999$
	English vs Java	X	$t(11) = -3.259, p = .023^*$	$t(11) = 0.351, p = .999$	$t(11) = 0.779, p = .999$

	Dutch vs English	X	$t(11) = 1.597, p = .415$	$t(11) = 0.498, p = .999$	$t(11) = -0.162, p = .999$
LP	Dutch vs Java	X	$t(11) = -1.139, p = .840$	$t(11) = 1.128, p = .849$	$t(11) = 1.830, p = .284$
	English vs Java	X	$t(11) = -0.646, p = .999$	$t(11) = 2.683, p = .064$	$t(11) = 2.953, p = .039^*$
	Dutch vs English	X	$t(11) = -0.671, p = .999$	$t(11) = -1.922, p = .243$	$t(11) = -1.048, p = .951$
RP	Dutch vs Java	X	$t(11) = -2.438, p = .099$	$t(11) = 0.857, p = .999$	$t(11) = 1.914, p = .250$
	English vs Java	X	$t(11) = -1.607, p = .409$	$t(11) = 1.447, p = .530$	$t(11) = 2.300, p = .130$
	Dutch vs English	X	$t(11) = -0.508, p = .999$	$t(11) = -2.007, p = .210$	$t(11) = -1.707, p = .350$

#### Hemisphere \* Anteriority

Left	Dutch vs Java	X		X	X
	English vs Java	X		X	X
Right	Dutch vs English	X		X	X
	Dutch vs Java	X		X	X
	English vs Java	X		X	X
	Dutch vs English	X		X	X

#### Midline

Main	Dutch vs Java	X	$t(35) = -2.527, p = .048^*$	$t(35) = 3.660, p = .003^{**}$	$t(35) = 3.379, p = .005^{**}$
	English vs Java	X	$t(35) = -3.023, p = .008^{**}$	$t(35) = 2.822, p = .023^*$	$t(35) = 3.347, p = .006^{**}$
	Dutch vs English	X	$t(35) = 1.184, p = .734$	$t(35) = -0.065, p = .999$	$t(35) = -0.426, p = .999$

#### Grammaticality \* Anteriority

MA	Dutch vs Java	X	$t(11) = -1.383, p = .582$	$t(11) = 2.079, p = .190$	$t(11) = 0.373, p = .999$
	English vs Java	X	$t(11) = -2.867, p = .046^*$	$t(11) = 0.536, p = .999$	$t(11) = -0.200, p = .999$
	Dutch vs English	X	$t(11) = 2.405, p = .105$	$t(11) = 1.211, p = .750$	$t(11) = 0.662, p = .999$

MC	Dutch vs Java	X	$t(11) = -1.344, p = .620$	$t(11) = 1.894, p = .250$	$t(11) = 2.368, p = .112$
	English vs Java	X	$t(11) = -1.894, p = .250$	$t(11) = 1.589, p = .420$	$t(11) = 2.578, p = .077$
MP	Dutch vs English	X	$t(11) = 0.669, p = .999$	$t(11) = -0.350, p = .999$	$t(11) = -0.575, p = .999$
	Dutch vs Java	X	$t(11) = -1.555, p = .440$	$t(11) = 2.188, p = .153$	$t(11) = 3.082, p = .031^*$
	English vs Java	X	$t(11) = -0.542, p = .999$	$t(11) = 3.092, p = .031^*$	$t(11) = 4.002, p = .006^{**}$
	Dutch vs English	X	$t(11) = -1.182, p = .790$	$t(11) = -1.195, p = .772$	$t(11) = -1.030, p = .976$

Note: Post hoc t-tests were only performed for time windows where a significant or marginally significant main effect of language was found, or if there was a significant or marginally significant interaction between grammaticality and anteriority or grammaticality and hemisphere. The table presents p-values after correction for multiple comparisons with Bonferroni corrections. \* indicates p-value below .05, \*\* indicates p-value below .01, \*\*\* indicates p-value below .001.

