The Office Pokémon GO IV Calculator

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- Taiwan OpenOffice/LibreOffice community
- Apache OpenOffice PMC
- Women in FOSS in Taiwan

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- Taiwan OpenOffice/LibreOffice community
- Apache OpenOffice PMC
- Women in FOSS in Taiwan
- A game player for almost three decades.
  - MS-DOS, Windows 95, 98, Linux Steam
  - PC game, MUD, Wii, mobile games
  - My favorite genre: RPG

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All in all,
it started as a spreadsheet.

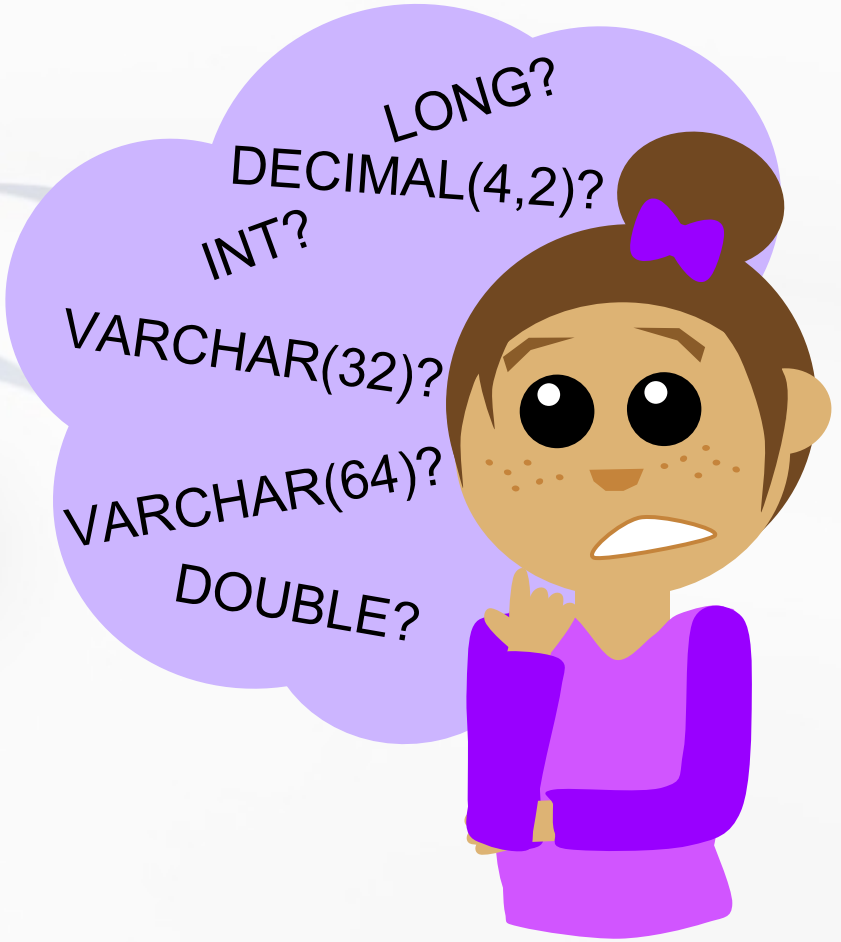
A Spreadsheet

- A spreadsheet is a convenient place to store data.

	A	B	C
1	Name	Age	Score
2	Jean Perry	19	67
3	Timothy Powell	16	52.6
4	Janice Jenkins	15	55.4
5	Craig Long	16	62.6
6	Jeremy Wilson	20	92.6
7	Steven Alexander	17	66.3
8	Irene Watson	16	95.5
9	Shirley Patterson	18	60.5
10	Jennifer Williams	15	74.6
11	Johnny Bennett	22	68.9
12	Tammy Cooper	18	72
13	Laura Thomas	17	88.8
14	Gary Adams	22	51.7
15	Juan Turner	22	84.2
16	Evelyn Hernandez	21	83.6

A Spreadsheet

- You don’t have to worry about the meta-data: data types, size, precision, etc.



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I use spreadsheets to store all kinds of daily information.

For example, …

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Journal Account

	A	B	C	D	E
1	Date	Summary	Income	Expense	Balance
2	2017/1/4	Lunch		$4	$8,476
3	2017/1/4	Bus		$3	$8,473
4	2017/1/5	Salary	$1,800		$10,273
5	2017/1/5	Lunch		$3	$10,270
6	2017/1/5	Coffee		$3	$10,267
7	2017/1/5	Shoes		$40	$10,227
8	2017/1/5	Eggs		$2	$10,225
9	2017/1/6	Lunch		$4	$10,221
10	2017/1/6	Bus		$3	$10,218
11	2017/1/6	Milk		$4	$10,214
12	2017/1/7	Lunch		$3	$10,211
13	2017/1/7	Bus		$3	$10,208

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Students' Scores

	A	B	C	D	E
1	Class	No.	Name	Mid exam	Final exam
2	A	1	Jean Perry	67	57
3	A	2	Timothy Powell	78	81
4	A	3	Janice Jenkins	73	65
5	B	4	Craig Long	67	59
6	B	5	Jeremy Wilson	54	46
7	B	6	Steven Alexander	69	59
8	A	7	Irene Watson	70	70
9	B	8	Shirley Patterson	99	98
10	A	9	Jennifer Williams	84	91
11	B	10	Johnny Bennett	66	69
12	A	11	Tammy Cooper	88	82
13	B	12	Laura Thomas	71	80

Attendees List

	A	B	C	D	E
1	No.	Name	Email	Telephone	Lunch
2	1	Michelle Stewart	michelle@example.com	0994827836	Yes
3	2	Albert Foster	albert@example.com	0962452823	Yes
4	3	Sara Diaz	sara@example.com	0916432729	No
5	4	Joe Edwards	joe@example.com	0989002701	No
6	5	Benjamin Peterson	benjamin@example.com	0987855818	Yes
7	6	Larry Alexander	larry@example.com	0917677574	Yes
8	7	Alice Cook	alice@example.com	0980602581	Yes
9	8	Doris Barnes	doris@example.com	0924878068	Yes
10	9	Clarence Washington	clarence@example.com	0909392077	Yes
11	10	Stephanie Campbell	stephanie@example.com	0913017227	No
12	11	Christina Davis	christina@example.com	0918238374	No
13	12	Patricia Russell	patricia@example.com	0967173377	No
14	13	Katherine Martinez	katherine@example.com	0931979897	No
15	14	Brian Thompson	brian@example.com	0987006117	Yes
16	15	Jose Murphy	jose@example.com	0994533627	No
17	16	Samuel Jenkins	samuel@example.com	0957094245	Yes

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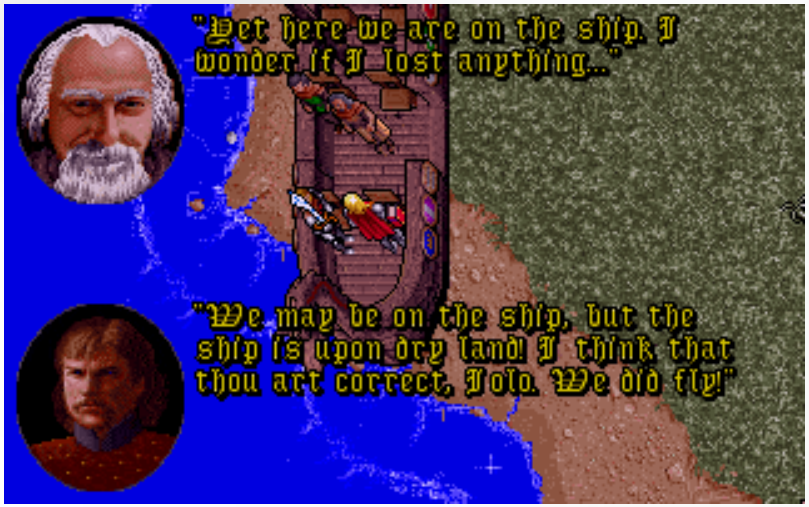
This is also true when it comes to games.

Lost Items in Ultima VII Part Two: Serpent Isle

	A	B	C	D
1	Person	Part	Item	Replacement
9	imacat	right hand	spellbook	pumice
13	imacat	backpack	blackrock-order serpent	fine stockings
28	Iolo	left hand		pumpkin
45	Dupre	right hand	mageband sword	blue egg
60	Shamino	right hand	magic bow	bear skull
61	Shamino	left hand		odd hairbrush



Plants and Their Costs in Plants vs. Zombies

	A	B	C
1	Name	$	C
2	Peashooter	100	☼
3	Sunflower	50	☼
4	Cherry Bomb	150	☼
5	Wall-nut	50	☼
6	Potato Mine	25	☼
7	Snow Pea	175	☼
8	Chomper	150	☼
9	Repeater	200	☼
10	Puff-shroom	0	☽
11	Sun-shroom	25	☽
12	Fume-shroom	75	☽
13	Grave Buster	75	☼
14	Hypno-shroom	75	☽
15	Scaredy-shroom	25	☽

Heroes in Sanctuary Battle (Chinese)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	#	杯緣子	別	位	類	100	☆	品階	醒	預	+8	右	右	滿
2	1	月騎	♀	中	敏	100	5	紅+1	↺	1	108	關		
3	2	遊俠	♀	後	敏	100	5	紅+1	↺	1	108	關⇧		
4	3	全能騎士	♂	前	力	100	5	紅+1	↺		108	關⇧		
5	4	復仇之魂	♀	後	敏	100	5	紅+1	↺	1	108	關		
6	5	白虎	♀	後	敏	100	5	紅+1	↺		108	征⇧		
7	6	巫妖	♀	中	智	100	5	紅+1	†		108	征		
8	7	修補匠	♂	中	智	100	5	紅+1	↺	1	108	關⇧		
9	8	雙頭龍	♂	中	智	100	5	紅+1	↺		108	競		
10	9	光之守衛	♂	後	智	100	5	紅+1	↺		108	征⇧		
11	10	黑暗先知	♀	中	智	100	5	紅+1	↺	8	108	征		
12	11	巨魔戰將	♂	中	敏	100	5	紅+1	↺	1	108	征⇧		
13	12	黑暗騎士	♂	前	力	100	5	紅+1	↺		108	競		
14	13	獸人術士	♂	中	智	100	5	紅+1	↺	2	108	公		
15	14	風行者	♀	後	智	100	5	紅+1	†		108	關		
16	15	小鹿	♀	後	智	100	5	紅+1	↺	1	108	關⇧		
17	16	火女	♀	中	智	100	5	紅+1	↺		108	關⇧		
18	17	冰女	♀	中	智	100	5	紅+1	↺		108	關		
19	18	機槍兵	♂	後	敏	100	5	紅+1			108	星		
20	19	猴子	♂	中	敏	100	5	紅+1	↺		108	公		
21	20	小魚人	♂	前	敏	100	5	紅+1	↺		108	無		
22	21	發條	♀	前	力	100	5	紅+1	↺		108	無		
23	22	艾吉奧	♂	前	敏	100	5	紅+1	↺		108	無		
24	23	老鹿	♂	中	智	100	5	紅+1	↺	2	108	關顛		
25	24	劇毒	♀	中	敏	100	5	紅+1	↺		108	無		
26	25	船長	♂	前	力	100	5	紅+1	†		108	關⇧		
27	26	梅杜莎	♀	中	敏	100	5	紅+1	↺		108	關		
28	27	機甲浣熊	♂	後	智	100	5	紅+1		5	108	星		
29	28	骷髏射手	♂	後	敏	100	5	紅+1	↺	1	108	關		
30	29	軍團指揮	♀	前	力	100	5	紅+1	↺	2	108	顛		
31	30	炸彈人	♂	後	智	100	5	紅+1	↺	1	108	關夢		

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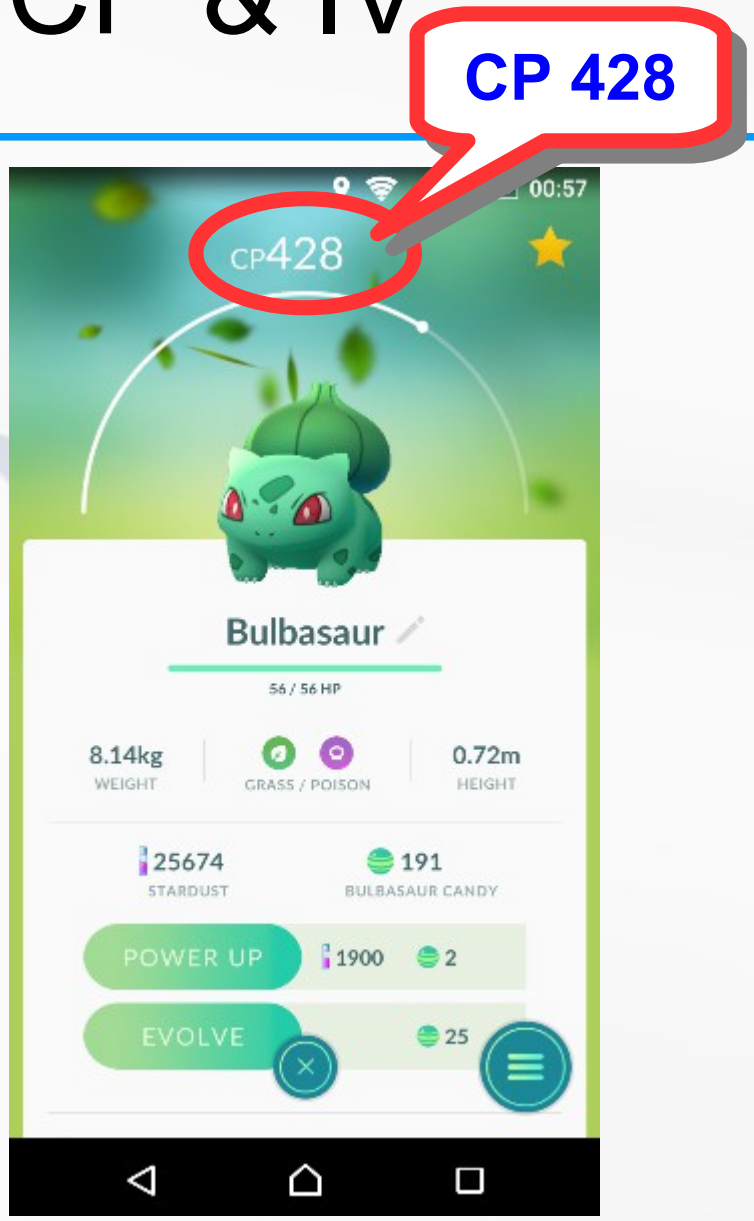
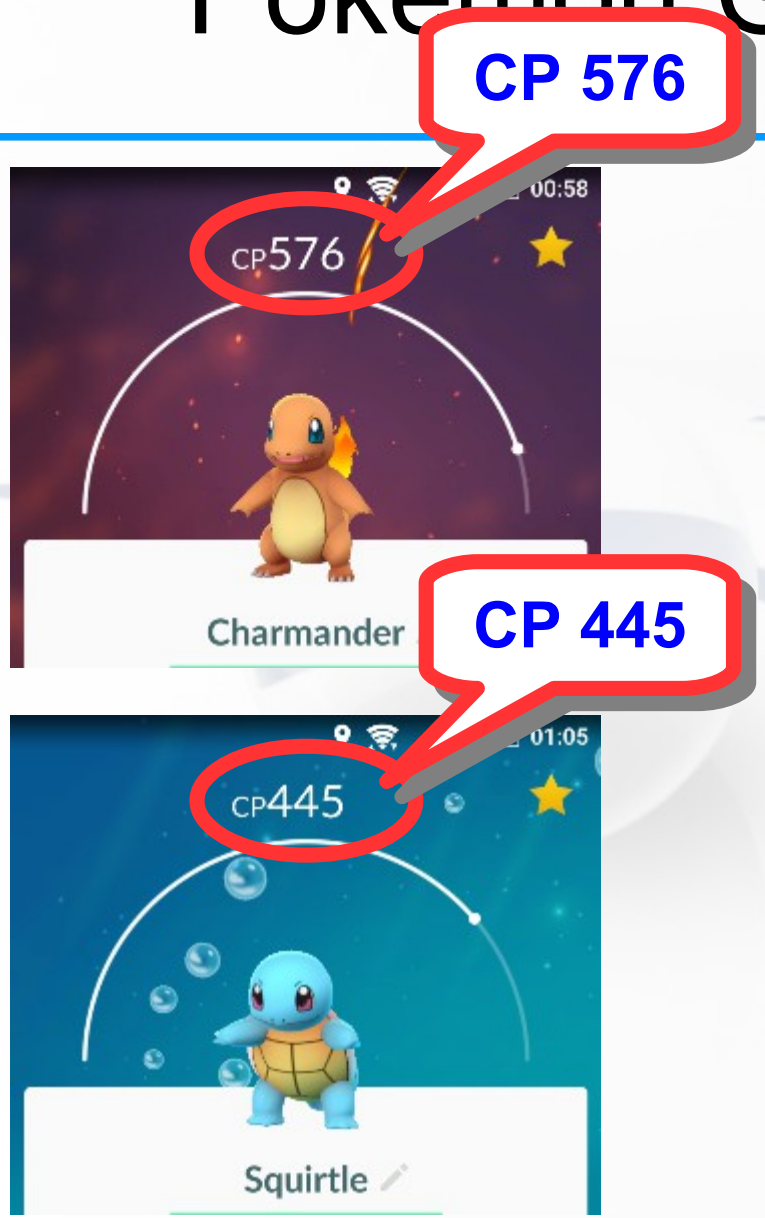
Now it goes for Pokémon GO.

Pokémon GO CP & IV

- In Pokémon GO, every Pokémon has its CP (combat power), that indicates how strong it is.



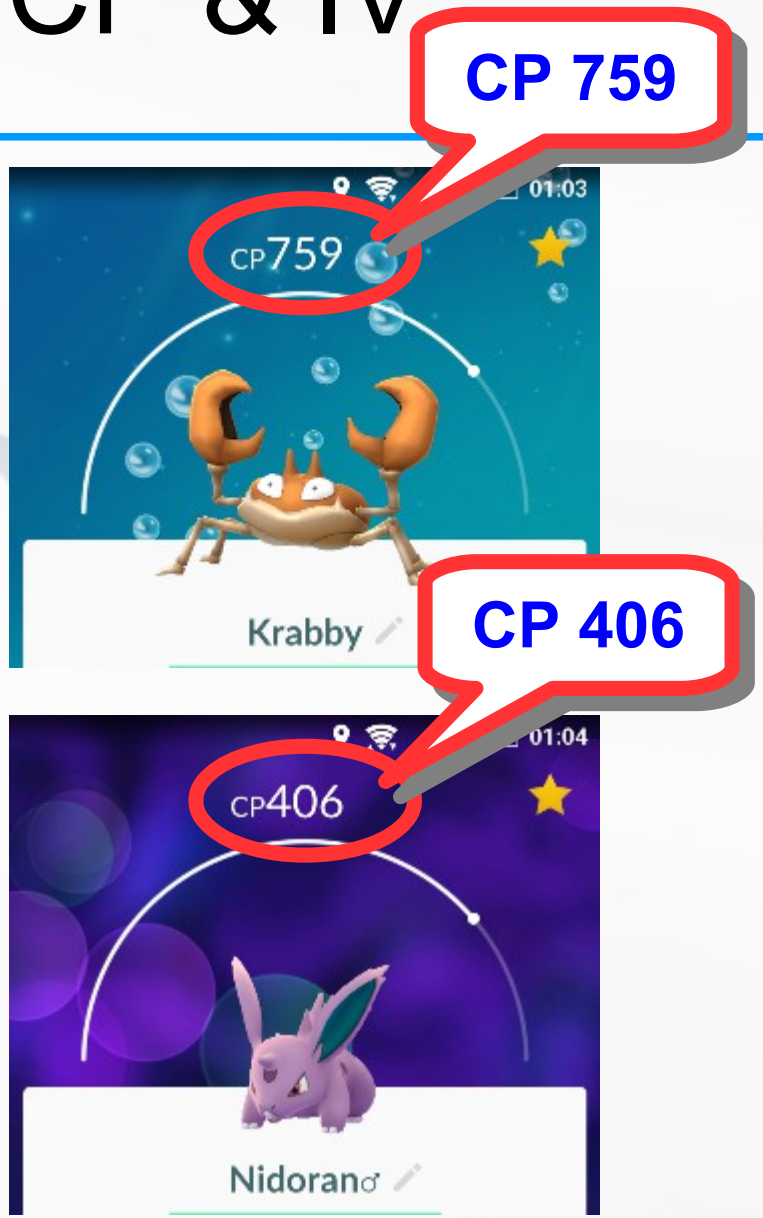
Pokémon GO CP & IV



- We often compare Pokémons by their CP to know which one is stronger than the other.

Pokémon GO CP & IV

- Some species are just stronger than others.



Pokémon GO CP & IV

- But even within the same species, their CP may still be different. They are still different from one another.

Pokémon GO CP & IV

- Base stats
  - Pokémons of the same species share the same set of base stats.

- Pikachu

  - Base Attack: 112
  - Base Defense: 101
  - Base Stamina: 70

- Slowbro

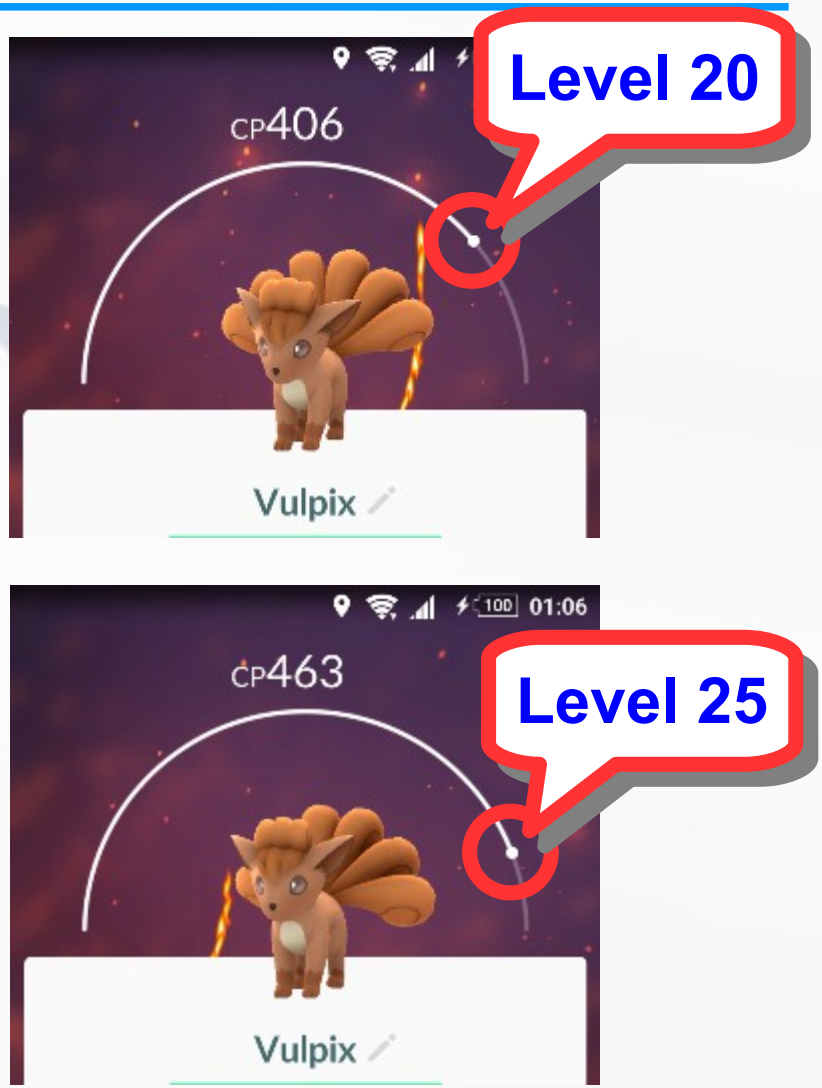
  - Base Attack: 177
  - Base Defense: 194
  - Base Stamina: 190

Pokémon GO CP & IV

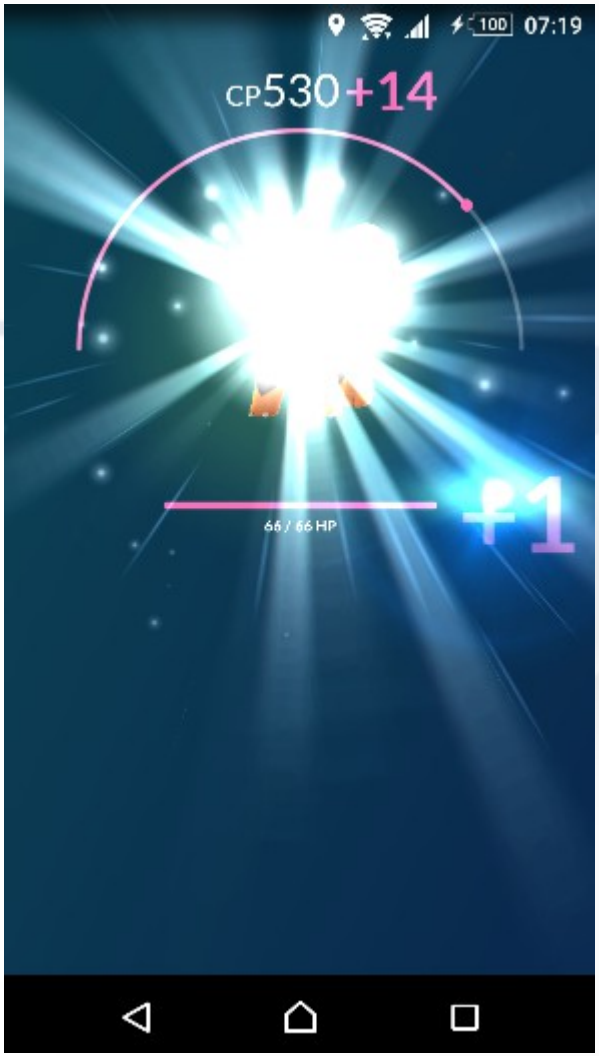
- Individual values (IV)
  - In addition, Pokémons have their own individual values (IV). IV are added to the base stats. They range from 0 to 15.
    - IV Attack: 0~15
    - IV Defense: 0~15
    - IV Stamina: 0~15

Pokémon GO CP & IV

- Level
  - Pokémons also have their levels. Levels are indicated by the arc below CP.



Pokémon GO CP & IV



- Level
  - Levels are advanced by “Power Up”.
  - Each “Power Up” advanced the level by 0.5.

Pokémon GO CP & IV

- To get the strongest Pokémon, we…
  1. Choose strong species with high base stats;
  2. Within a species, pick the Pokémon with highest IV;
  3. Power up to maximum advance its level.

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Question:
How do we know their IV?

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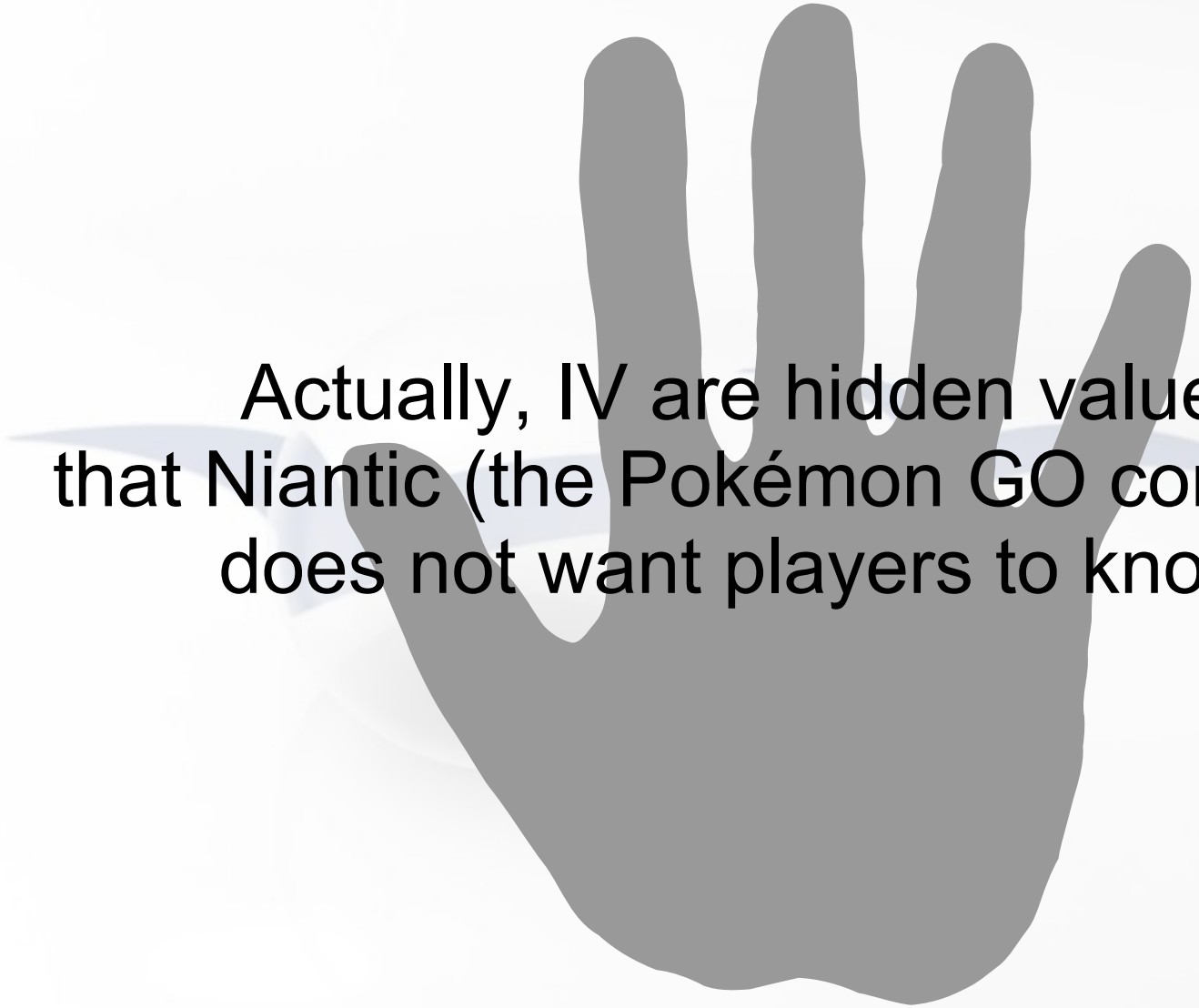

Actually, IV are hidden values
that Niantic (the Pokémon GO company)
does not want players to know.

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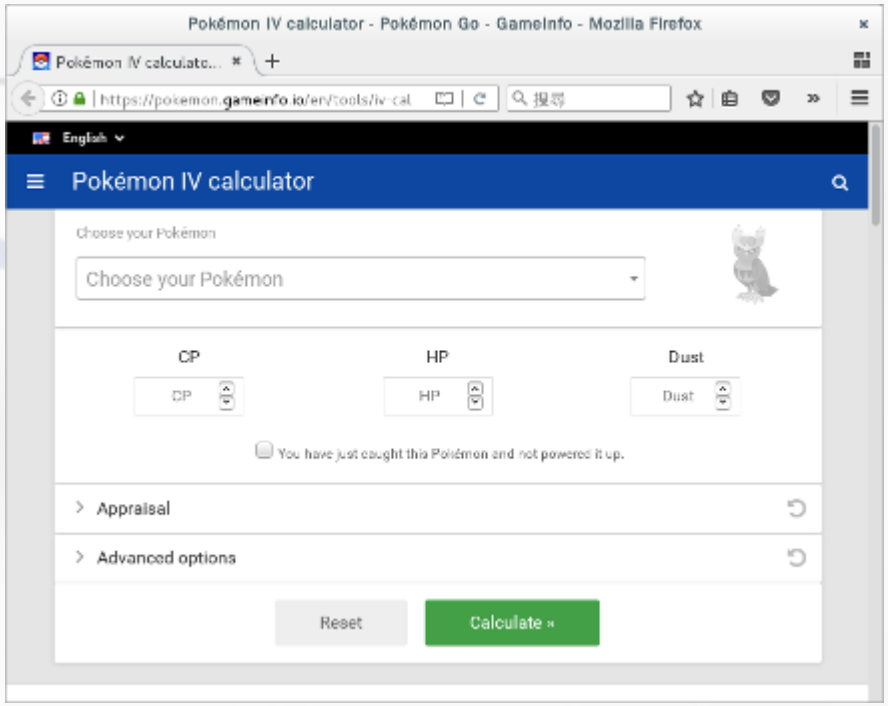
You will be banned
if you are found to peep the IV.

But, we are hackers.

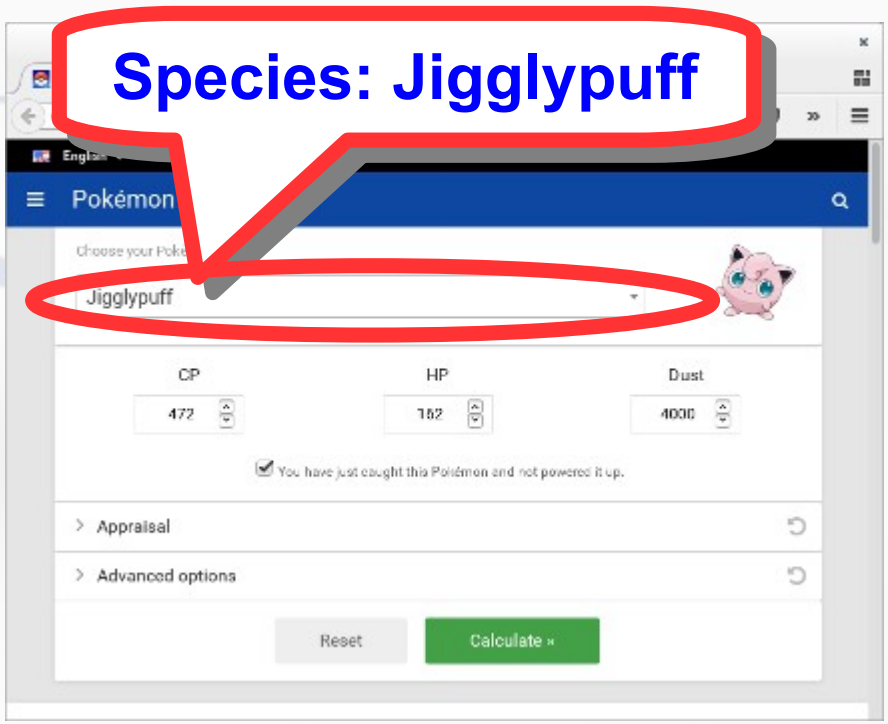
We can still infer the IV
from the given hints and clues.

Pokémon GO IV

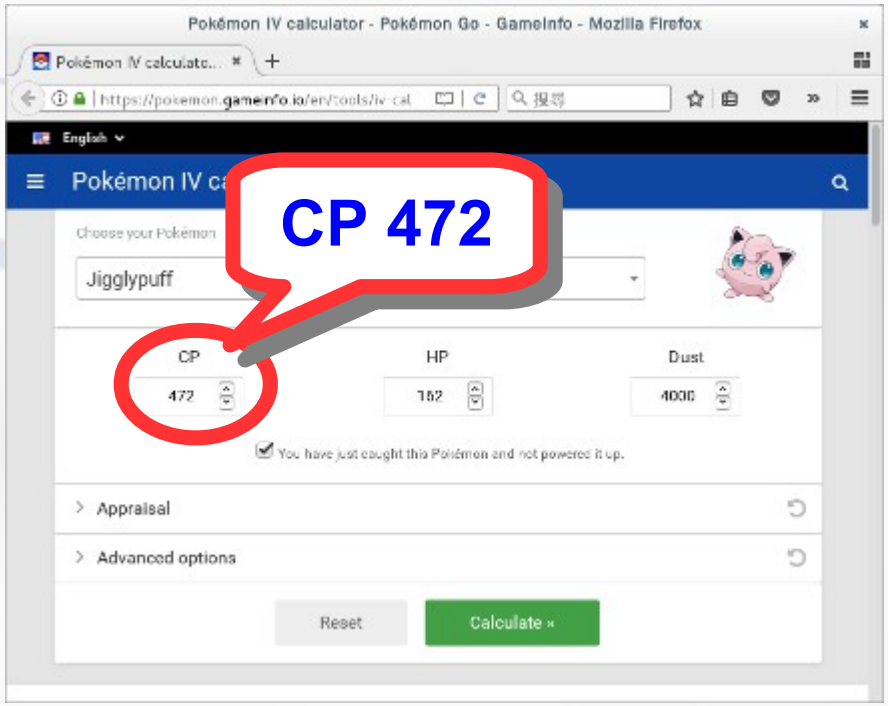
- There are several websites that calculates Pokémon IV for you.



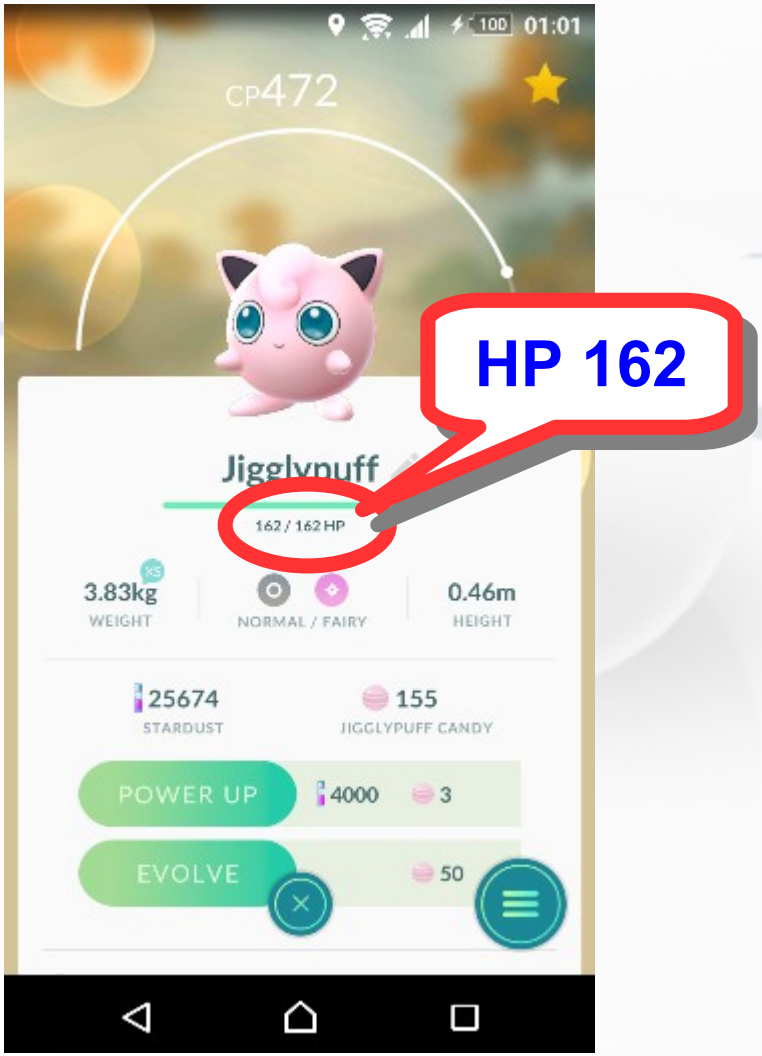
Pokémon GO IV

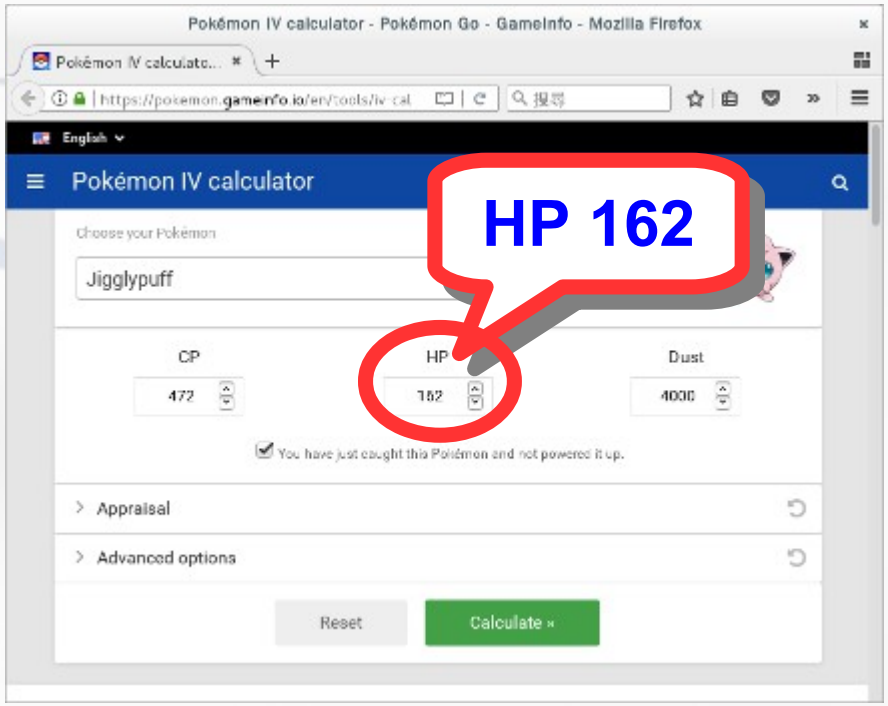


Pokémon GO IV

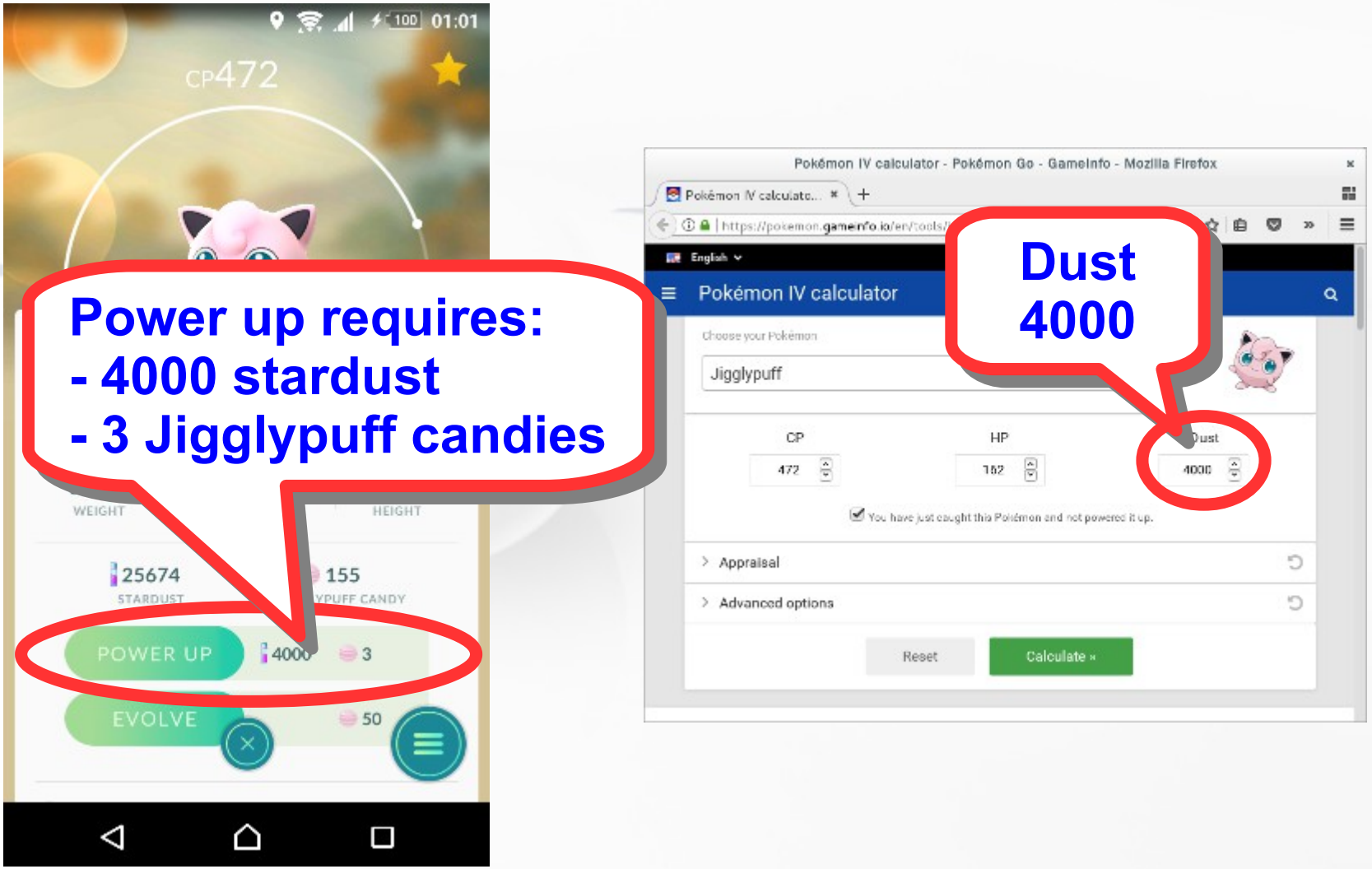


Pokémon GO IV

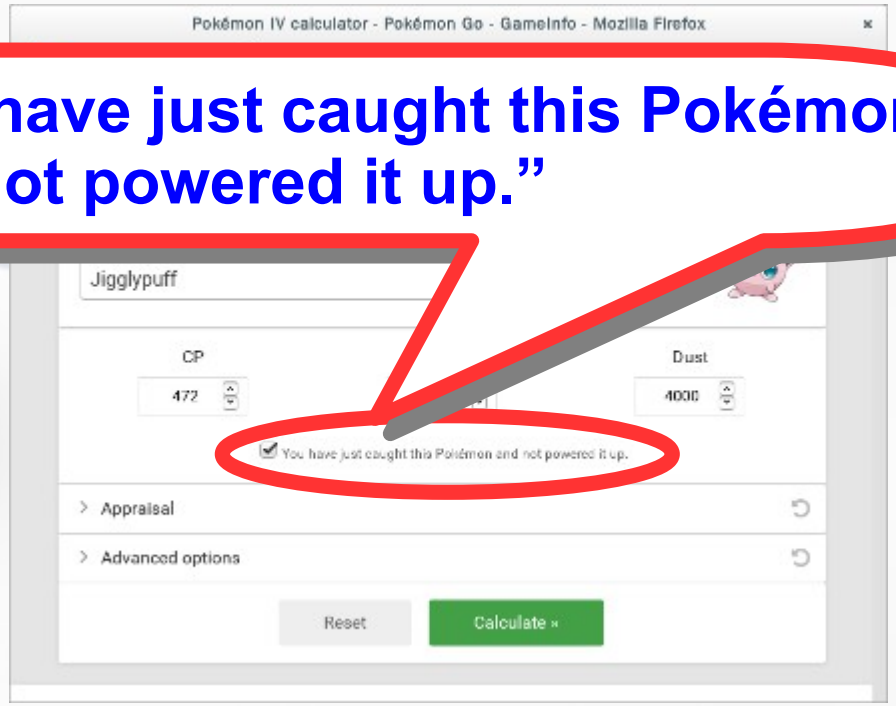




Pokémon GO IV



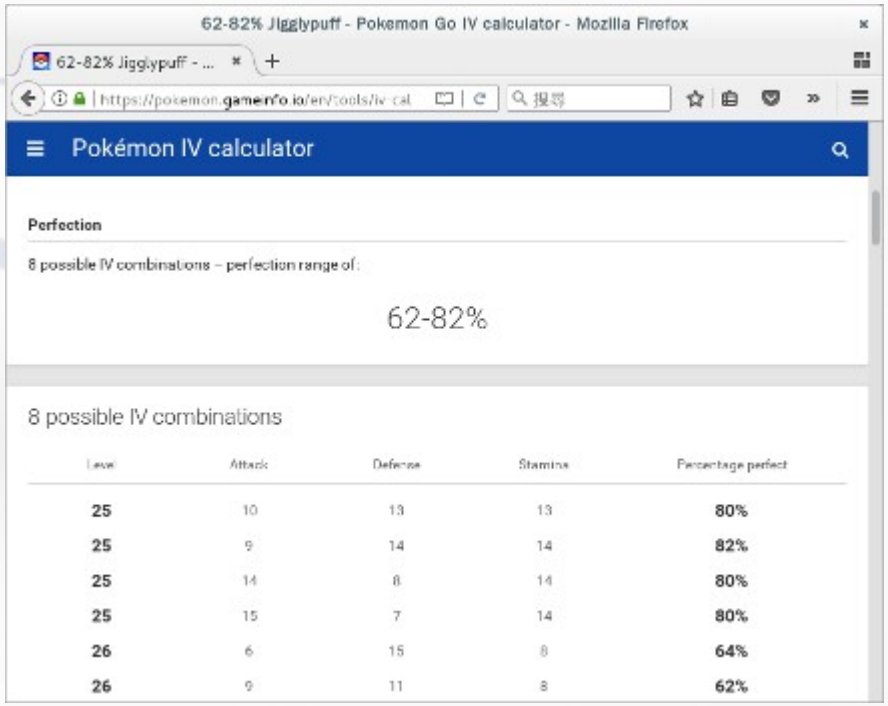
Pokémon GO IV



"You have just caught this Pokémon and not powered it up."

Pokémon GO IV

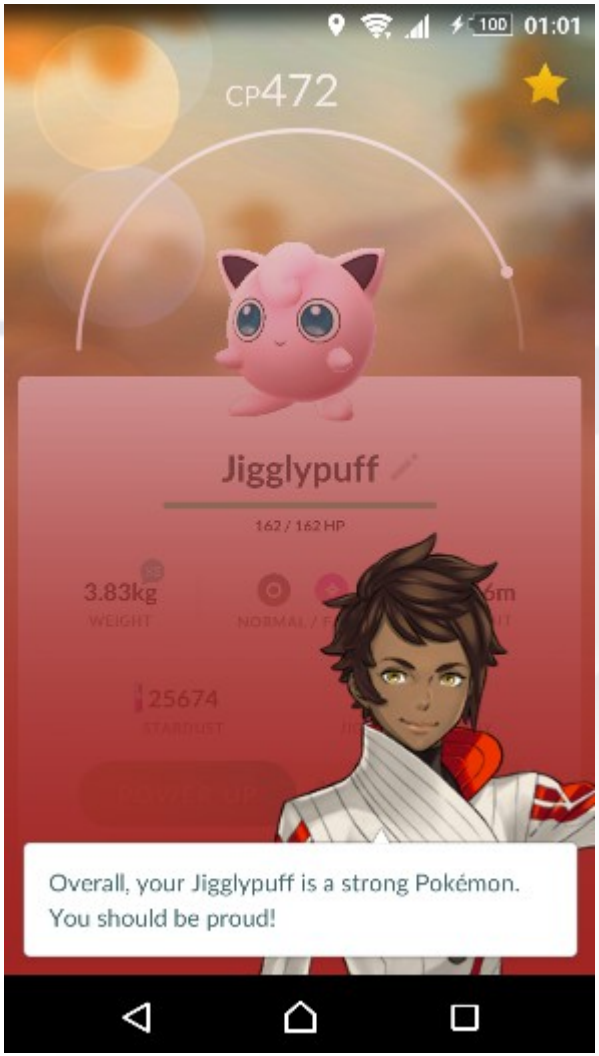
- Found 8 possible IV combinations.

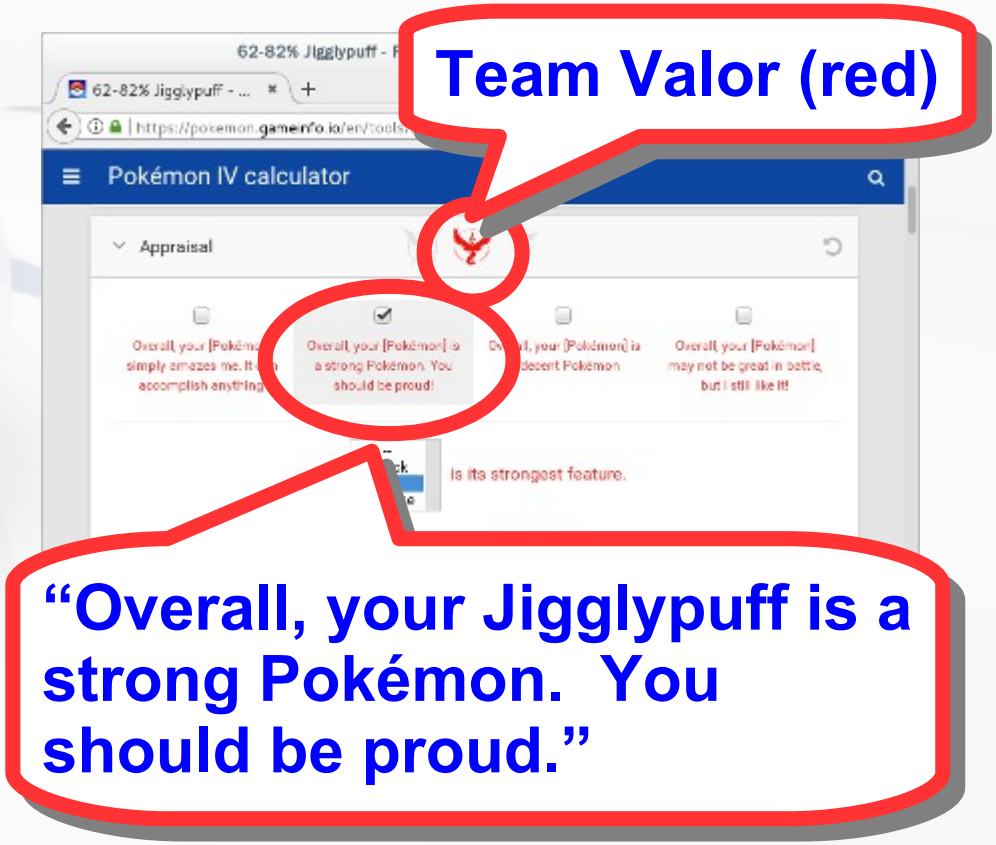


Refine by Appraisal

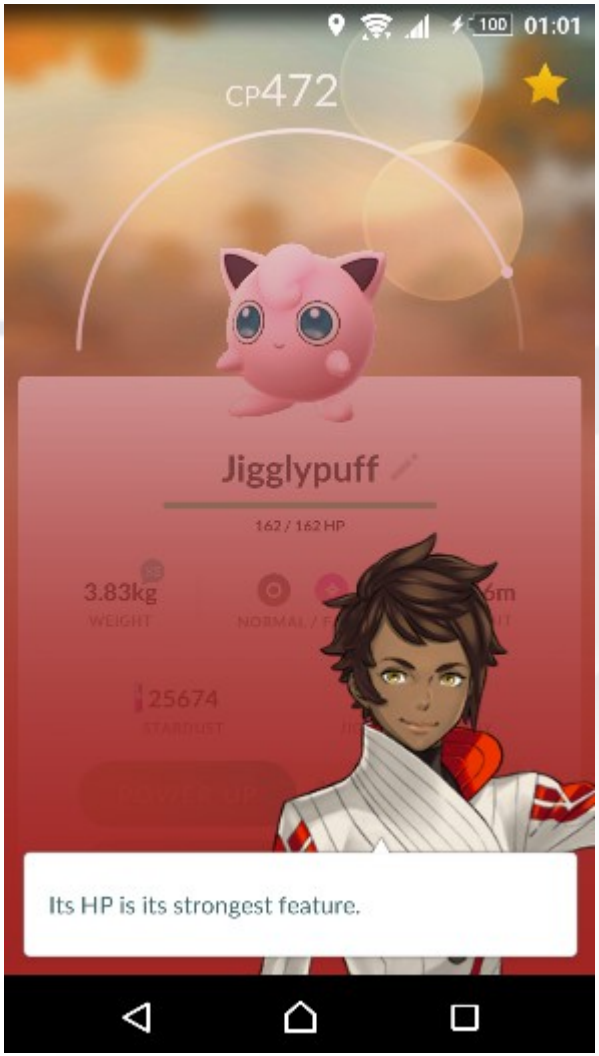
- We further refine the result by our team leader's appraisal.

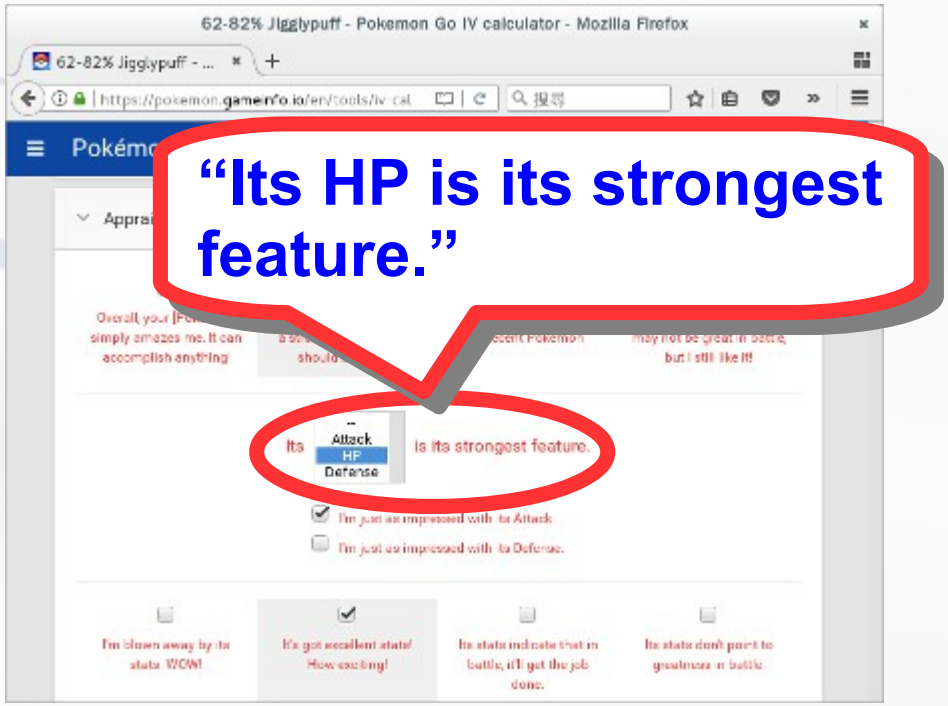
Refine by Appraisal



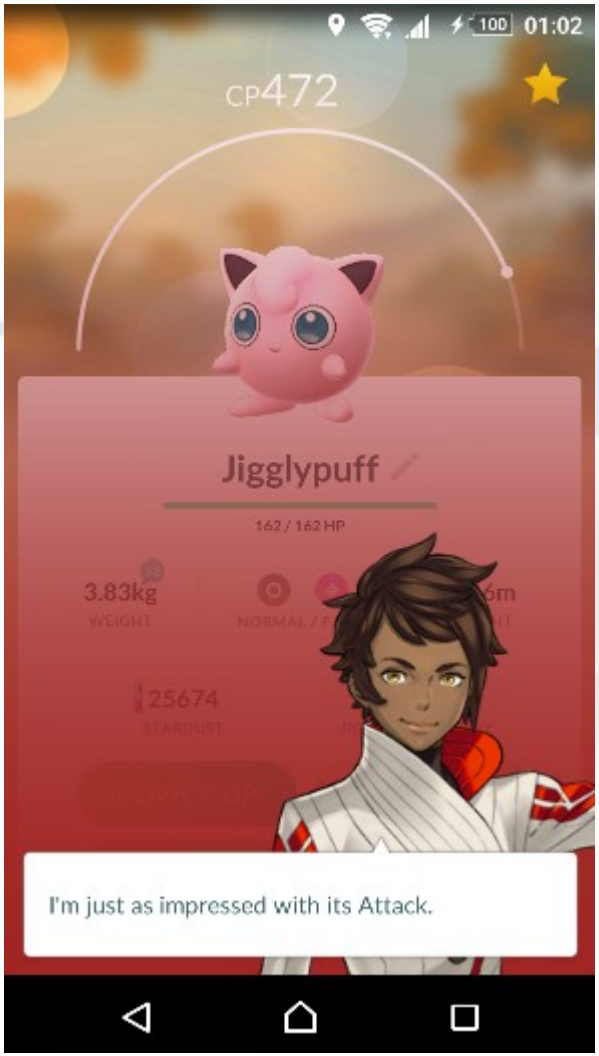


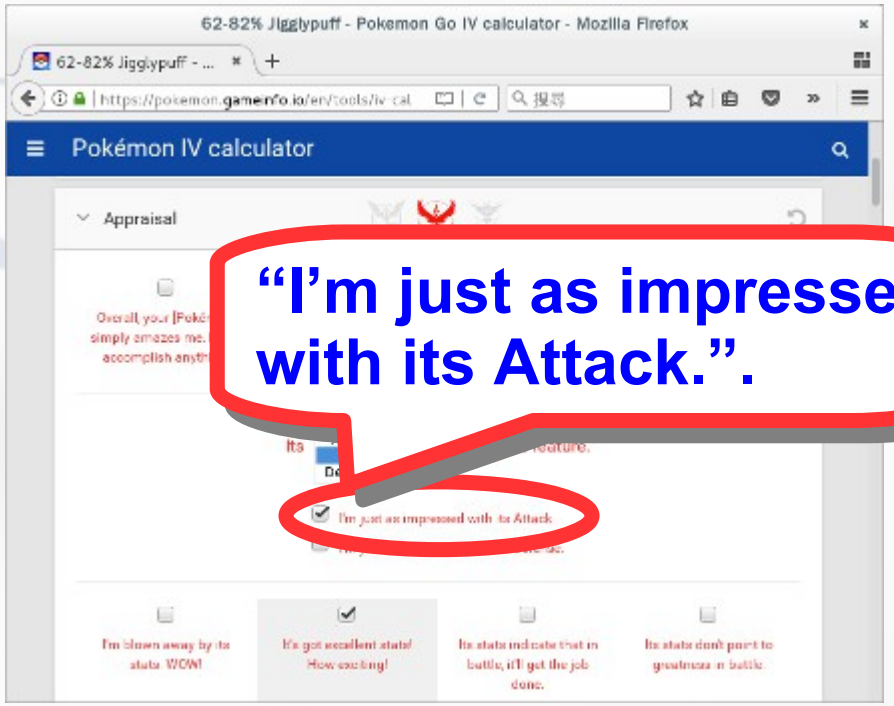
Refine by Appraisal





Refine by Appraisal





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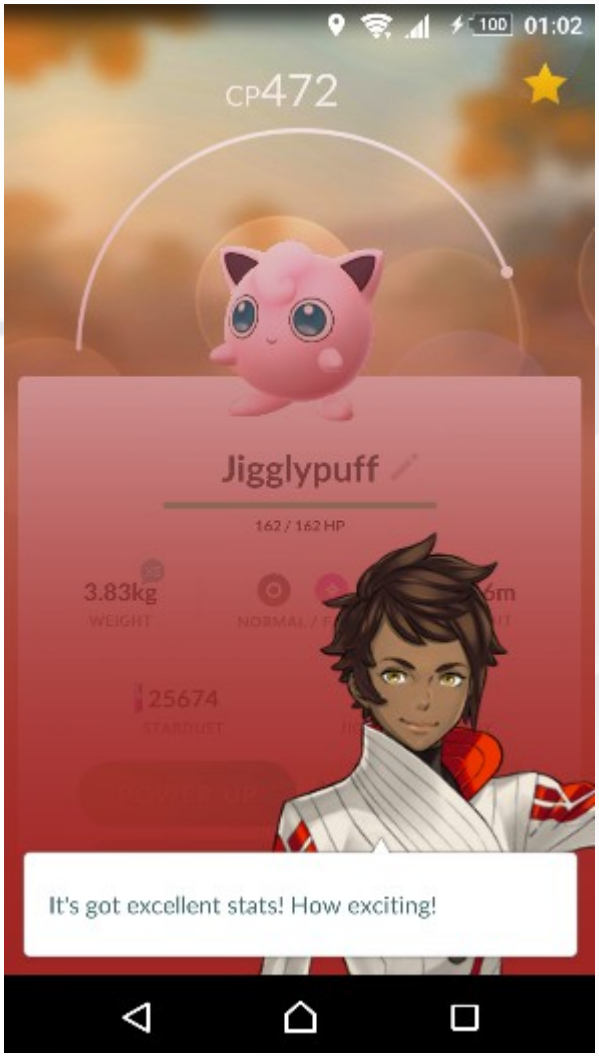
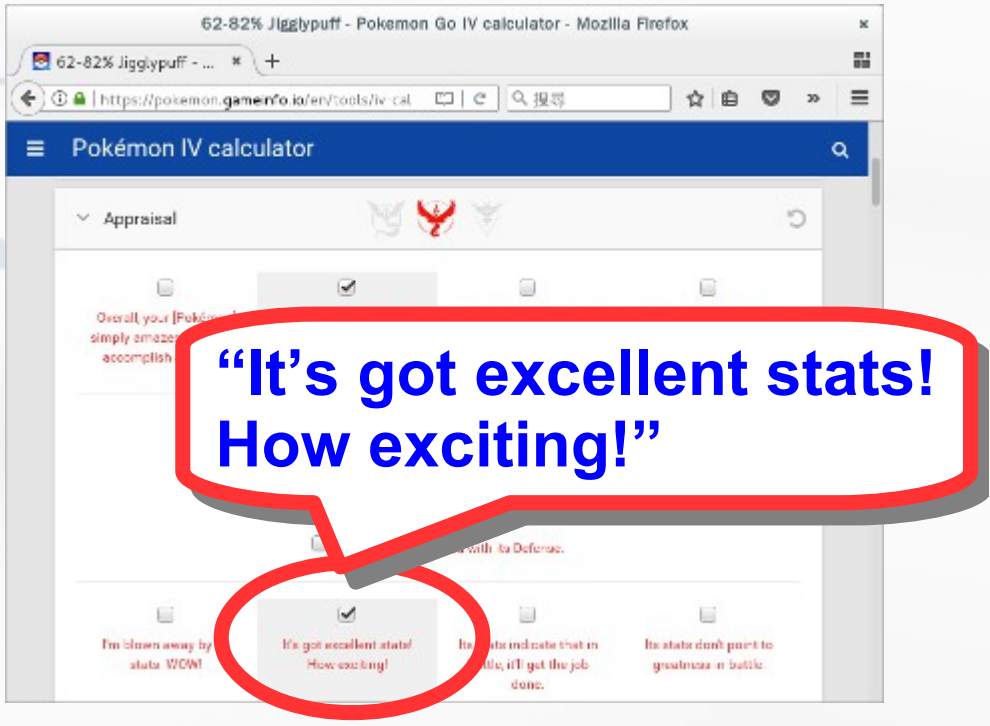
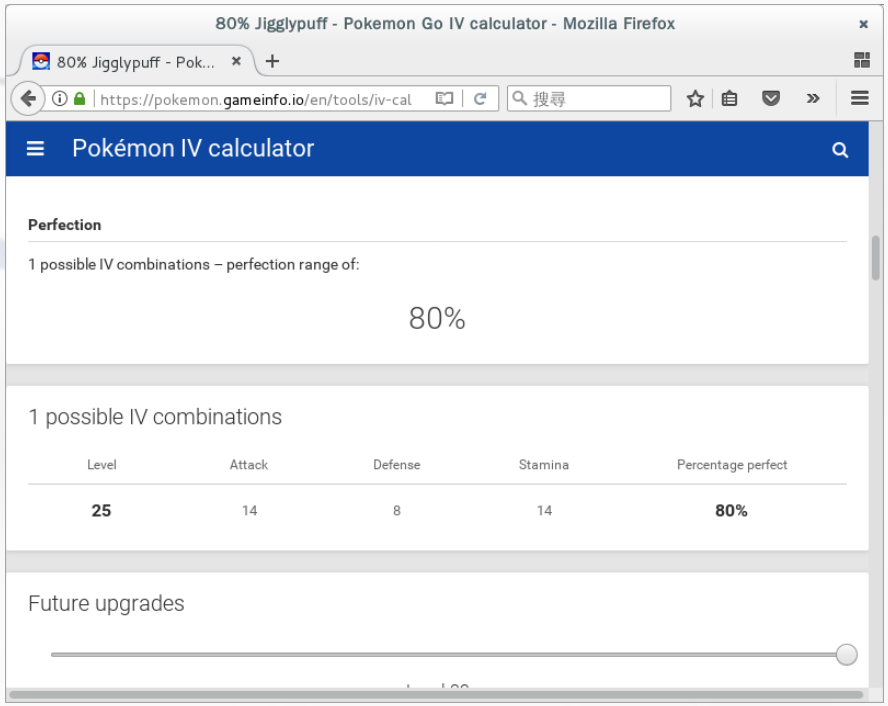




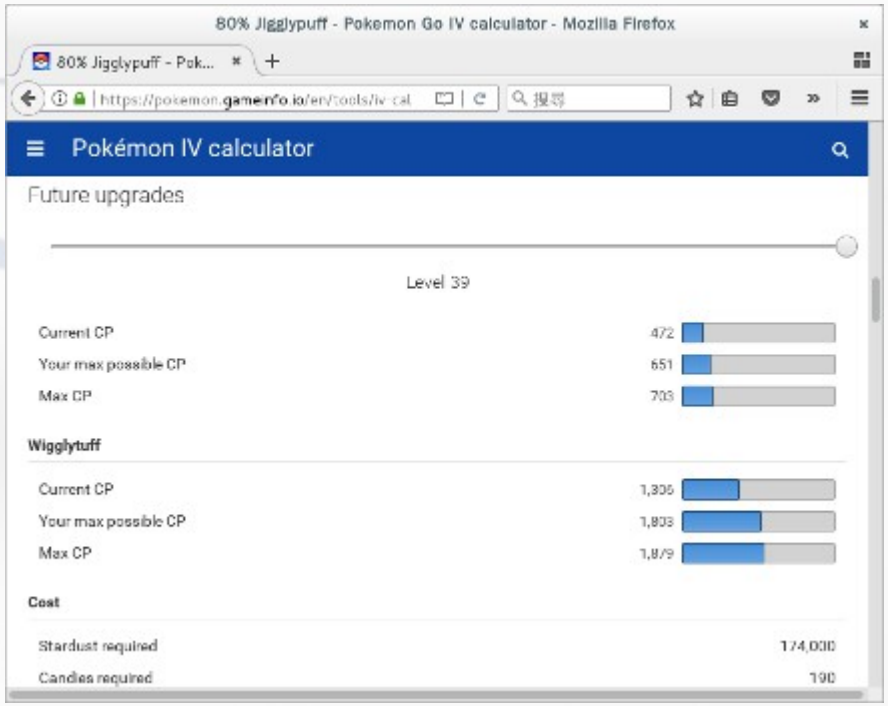
Refine by Appraisal

- Found!
  - Level 25
  - Attack 14
  - Defense 8
  - Stamina 14



Refine by Appraisal

- Future power-up estimation, for Pokémon level 39
  - Max CP: 1803
  - Require 174,000 stardust
  - Require 190 Jigglypuff candies



Pokémon GO Data Sheet

	A	B	C	D	E	F	G	H	I
1	Pokémon	CP	Lv	Atk	Def	Sta	IV	Max CP	
2	Bulbasaur	428	16	9	15	15	87%	2193	
3	Ivysaur	883	20	15	15	14	98%	2250	
4	Venusaur	2138	20	13	15	14	93%	2229	
5	Charmeleon	1199	29	14	15	10	87%	2315	
6	Charizard	1535	20	14	13	10	82%	2303	
7	Squirtle	445	20	14	13	11	84%	1970	

- Using the IV calculator, I created a spreadsheet to record my strongest Pokémons.

A More Advanced Spreadsheet

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Now I have a question …

A More Advanced Spreadsheet

- My Lapras has the following IV:
  - Level: 20, Attack: 13, Defense: 12, Stamina: 11
- For Pokémon level 39, to max power up:
  - 205,000 stardust, 218 Lapras candies, CP 2866

A More Advanced Spreadsheet

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  - Level: 20, Attack: 13, Defense: 12, Stamina: 11
- For Pokémon level 39, to max power up:
  - 205,000 stardust, 218 Lapras candies, CP 2866
- But I only have the following resources:
  - 237,436 stardust, ***29*** Larpas candies.

A More Advanced Spreadsheet

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  - Level: 20, Attack: 13, Defense: 12, Stamina: 11
- For Pokémon level 39, to max power up:
  - 205,000 stardust, 218 Lapras candies, CP 2866
- But I only have the following resources:
  - 237,436 stardust, ***29*** Larpas candies.
- What's its max CP under this limitation? Should I power it up?

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To answer this question,
I need to be able to calculate CP myself.

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For a popular game like Pokémon GO,
someone must have hacked the formula.

And this is true.
With a little Google,
the CP formula is found.

The CP (Combat Power) Formula

$$Attack_{Level} = Attack \cdot CPM_{Level} = (Attack_{Base} + Attack_{IV}) \cdot CPM_{Level}$$
$$Defense_{Level} = Defense \cdot CPM_{Level} = (Defense_{Base} + Defense_{IV}) \cdot CPM_{Level}$$
$$Stamina_{Level} = Stamina \cdot CPM_{Level} = (Stamina_{Base} + Stamina_{IV}) \cdot CPM_{Level}$$
$$CP = \frac{Attack_{Level} \cdot \sqrt{Defense_{Level}} \cdot \sqrt{Stamina_{Level}}}{10}$$
$$= \frac{(Attack \cdot CPM_{Level}) \cdot \sqrt{Defense \cdot CPM_{Level}} \cdot \sqrt{Stamina \cdot CPM_{Level}}}{10}$$
$$= \frac{Attack \cdot \sqrt{Defense} \cdot \sqrt{Stamina} \cdot CPM_{Level}^2}{10}$$
$$= \frac{(Attack_{Base} + Attack_{IV}) \cdot \sqrt{Defense_{Base} + Defense_{IV}} \cdot \sqrt{Stamina_{Base} + Stamina_{IV}} \cdot CPM_{Level}^2}{10}$$

The CP (Combat Power) Formula

- Base stats
  - The basic attributes for each species
  - This can be found on the internet.

	A	B	C	D
1	Pokémon	Atk	Def	Sta
2	Bulbasaur	118	118	90
3	Ivysaur	151	151	120
4	Venusaur	198	198	160
5	Charmander	116	96	78
6	Charmeleon	158	129	116
7	Charizard	223	176	156
8	Squirtle	94	122	88
9	Wartortle	126	155	118
10	Blastoise	171	210	158
11	Caterpie	55	62	90
12	Metapod	45	94	100
13	Butterfree	167	151	120
14	Weedle	63	55	80

The CP (Combat Power) Formula

- CPM (CP multiplier)
  - A list of constants increase with level.
  - This can be found on the internet, too.
  - CPM of 0.5 levels are culculated at real time:

$$CP_{lv} = \sqrt{\frac{CP_{lv-0.5}^2 + CP_{lv+0.5}^2}{2}}$$

	A	B	C
1	Level	CP Multiplier	
2	1	0.094	
3	2	0.16639787	
4	3	0.21573247	
5	4	0.25572005	
6	5	0.29024988	
7	6	0.3210876	
8	7	0.34921268	
9	8	0.37523559	
10	9	0.39956728	
11	10	0.42250001	
12	11	0.44310755	
13	12	0.46279839	
14	13	0.48168495	
15	14	0.49985844	

The CP (Combat Power) Formula

- For example, my Butterfree is:
  - Base: Attack 167, Defense 151, Stamina 120
  - IV: Attack 14, Defense 15, Stamina 9
  - Level 22, CPM 0.62656713

$$CP = \frac{(Attack_{Base} + Attack_{IV}) \cdot \sqrt{Defense_{Base} + Defense_{IV}} \cdot \sqrt{Stamina_{Base} + Stamina_{IV}} \cdot CPM_{Level}^2}{10}$$

$$= \frac{(167 + 14) \cdot \sqrt{151 + 15} \cdot \sqrt{120 + 9} \cdot 0.62656713^2}{10} \simeq 1039.83$$

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For my Lapras problem,

My Larpas Problem

- The amount of stardust and candies to power up can be found on the internet, too.

	A	B	C	D	E
1	From	To	Dust	•	
2	1	1.5	200	1	
3	1.5	2	200	1	
4	2	2.5	200	1	
5	2.5	3	200	1	
6	3	3.5	400	1	
7	3.5	4	400	1	
8	4	4.5	400	1	
9	4.5	5	400	1	
10	5	5.5	600	1	
11	5.5	6	600	1	
12	6	6.5	600	1	
13	6.5	7	600	1	
14	7	7.5	800	1	
15	7.5	8	800	1	

My Larpas Problem

- With a total 29 candies, I can power up my Lapras from level 20 to level 25.

	B	C	D	E	F
1	To	Dust			
37	19	2200	2	Lapras	
38	19.5	2500	2	Dust	
39	20	2500	2	0	0
40	20.5	2500	2	2500	2
41	21	2500	2	5000	4
42	21.5	3000	3	8000	7
43	22	3000	3	11000	10
44	22.5	3000	3	14000	13
45	23	3000	3	17000	16
46	23.5	3500	3	20500	19
47	24	3500	3	24000	22
48	24.5	3500	3	27500	25
49	25	3500	3	31000	28
50	25.5	4000	3		

My Larpas Problem

- At level 25, my Lapras is:
  - Base: Attack 186, Defense 190, Stamina 260
  - IV: Attack 13, Defense 12, Stamina 11
  - Level 25, CPM 0.667934

$$CP = \frac{(Attack_{Base} + Attack_{IV}) \cdot \sqrt{Defense_{Base} + Defense_{IV}} \cdot \sqrt{Stamina_{Base} + Stamina_{IV}} \cdot CPM_{Level}^2}{10}$$

$$= \frac{(186 + 13) \cdot \sqrt{190 + 12} \cdot \sqrt{260 + 11} \cdot 0.667934^2}{10} \simeq 2077.21$$

A More Advanced Spreadsheet

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Lv	30											
2	Pokémon	CP	Lv	Atk	Def	Sta	IV	Ev.X	Dust	•	Ev.1	Ev.2	Ev.3
3	Bulbasaur	428	16	9	15	15	87%	2193	108600	96	428	683	1141
4	Ivysaur	883	20	15	15	14	98%	2250	91000	80	558	883	1463
5	Venusaur	2138	20	13	15	14	93%	2229	91000	80	549	872	1449
6	Charmeleon	1199	29	14	15	10	87%	2315	26000	22	664	1199	2184
7	Charizard	1535	20	14	13	10	82%	2303	91000	80	454	821	1498
8	Squirtle	445	20	14	13	11	84%	1970	91000	80	445	735	1281

- With the ability to calculate CP, I produced a more advanced spreadsheet to tell the potentials of my Pokémons.

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From a Spreadsheet to an Application

Knowing the CP formula,
My own CP calculator
is just one step away.

It is simply *brute force*.

The Pokémon GO IV Calculator

```
' Psuedo code
Found = Array()
For Level = 1 To 40 Step 0.5
 For StaIV = 0 To 15
  For AtkIV = 0 To 15
   For DefIV = 0 To 15
    If CalcCP(Level, AtkIV, DefIV, StaIV) = CP Then
     AddFound(Found, Level, AtkIV, DefIV, StaIV)
    End If
   Next IVDef
  Next IVAtk
 Next IVSta
Next Level
```

This runs
79×15×15×15=266,625 times.

This runs
79×15×15×15=266,625 times.

A HUGE number!!

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Refining the Brute Force

Refining the Brute Force

- Knowing the amount of stardust to power up limits the number of possible levels from 79 to 4.

	A	B	C	D
32	16	16.5	1900	2
33	16.5	17	1900	2
34	17	17.5	2200	2
35	17.5	18	2200	2
36	18	18.5	2200	2
37	18.5	19	2200	2
38	19	19.5	2500	2
39	19.5	20	2500	2
40	20	20.5	2500	2
41	20.5	21	2500	2
42	21	21.5	3000	3
43	21.5	22	3000	3
44	22	22.5	3000	3
45	22.5	23	3000	3
46	23	23.5	3500	3

Refining the Brute Force

- Newly-caught Pokémons only have whole-numbered levels.
  - The number of possible levels are further reduced to 2.

	A	B	C	D
32	16	16.5	1900	2
33	16.5	17	1900	2
34	17	17.5	2200	2
35	17.5	18	2200	2
36	18	18.5	2200	2
37	18.5	19	2200	2
38	19	19.5	2500	2
39	19.5	20	2500	2
40	20	20.5	2500	2
41	20.5	21	2500	2
42	21	21.5	3000	3
43	21.5	22	3000	3
44	22	22.5	3000	3
45	22.5	23	3000	3
46	23	23.5	3500	3

Refining the Brute Force

- *HP* is the value of $Stamina_{Level}$ (as a whole number).

$$HP = Stamina_{Level} = \left(Stamina_{Base} + Stamina_{IV} \right) \cdot CPM_{Level}$$

- This limits $Stamina_{IV}$ to one or two values.

The number of runs is reduced to 2×2×15×15=900 times.

The number of runs is reduced to 2×2×15×15=900 times.

A lot smaller.

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Further Refinement with Team Leader Appraisal

Team Leader Appraisal #1
The Total

- “Overall, your [Pokémon] simply amazes me. It can accomplish anything!”
  - $Atk_{IV} + Def_{IV} + Sta_{IV} \geq 37$
- “Overall, your [Pokémon] is a strong Pokémon. You should be proud!”
  - $30 \leq Atk_{IV} + Def_{IV} + Sta_{IV} \leq 36$
- “Overall, your [Pokémon] is a decent Pokémon.”
  - $23 \leq Atk_{IV} + Def_{IV} + Sta_{IV} \leq 29$
- “Overall, your [Pokémon] may not be great in battle, but I still like it!”
  - $Atk_{IV} + Def_{IV} + Sta_{IV} \leq 22$

Team Leader Appraisal #2
The Best Stats

- “Its HP/Attack/Defense is its strongest feature.”
- (Optional) “I'm just as impressed with its HP/Attack/Defense.”
  - The listed HP/Attack/Defense are equally its best stats.

Team Leader Appraisal #3
The Maximm Stat Value

- “I'm blown away by its stats. WOW!”
  - $\mathrm{Max}(Atk_{IV}, Def_{IV}, Sta_{IV}) = 15$
- “It's got excellent stats! How exciting!”
  - $\mathrm{Max}(Atk_{IV}, Def_{IV}, Sta_{IV}) = 13 \text{ or } 14$
- “Its stats indicate that in battle, it'll get the job done.”
  - $8 \leq \mathrm{Max}(Atk_{IV}, Def_{IV}, Sta_{IV}) \leq 12$
- “Its stats don't point to greatness in battle.”
  - $\mathrm{Max}(Atk_{IV}, Def_{IV}, Sta_{IV}) \leq 7$

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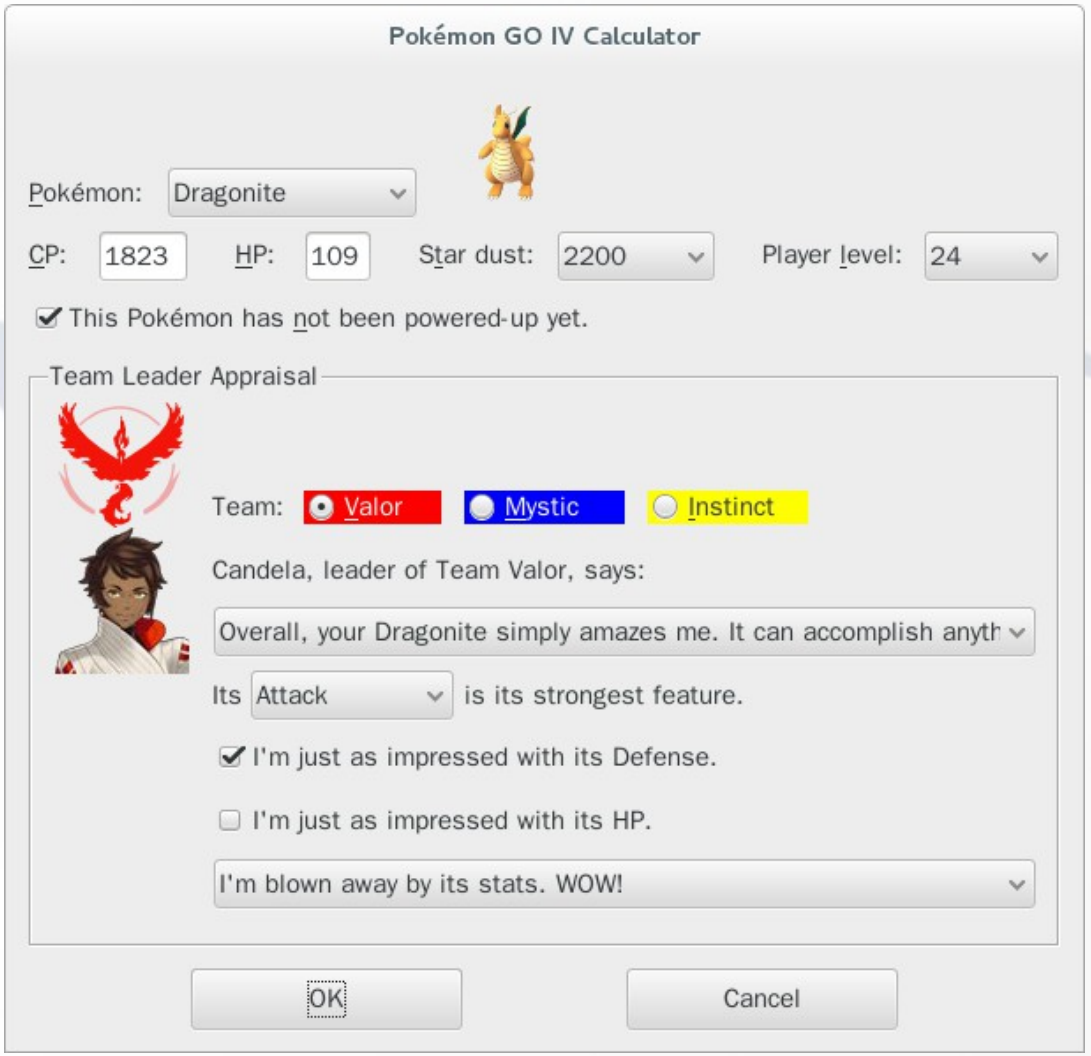
The Pokémon GO IV Calculator



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But things are not always so easy.

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Case #1

One morning in November when I woke up,
I found my second and third strongest
Pokémons, my Gyarados sisters,
become much stronger than I remembered!

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In fact, not only my Gyarados sisters,
but all of them have different CP!

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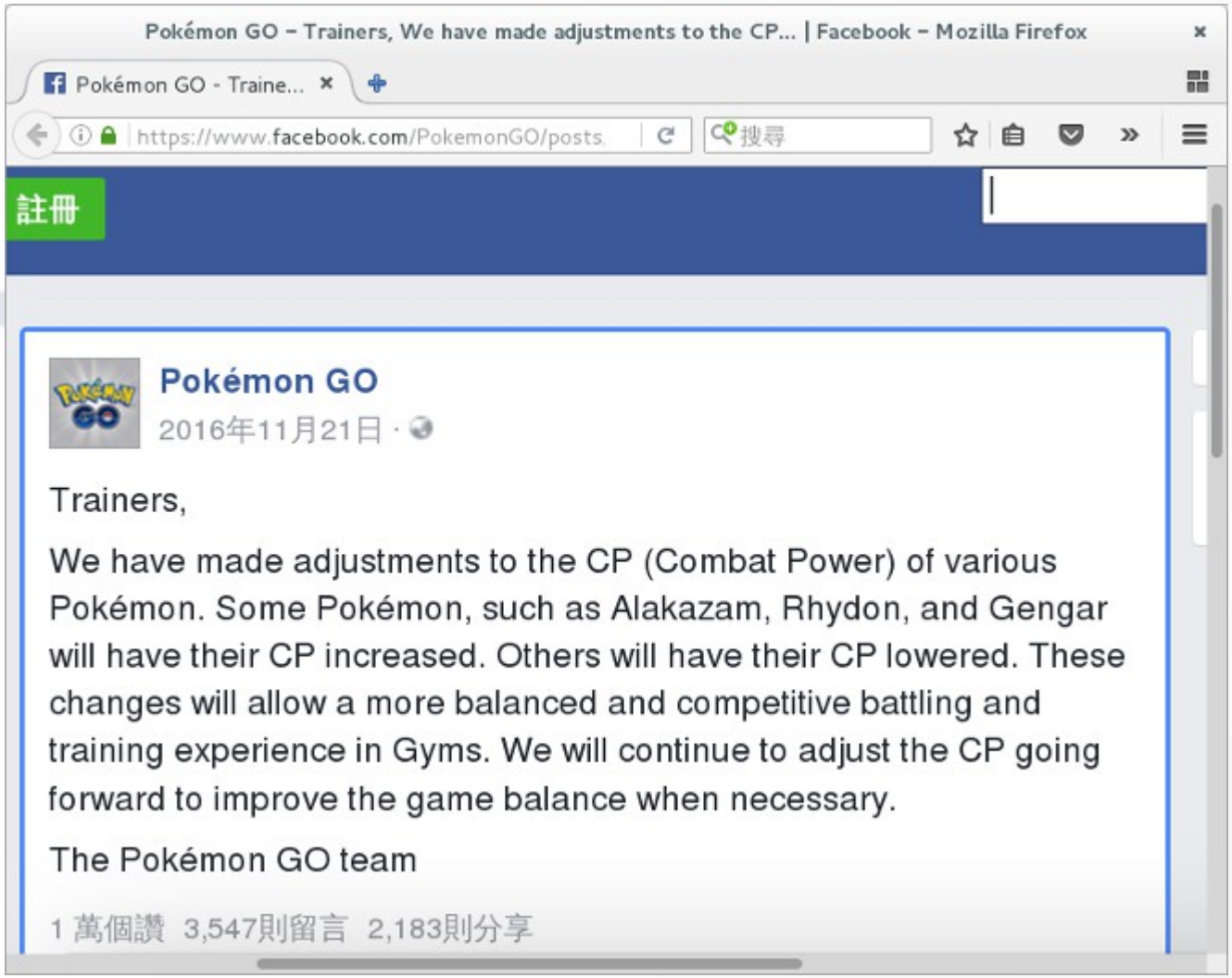
I went to the Pokémon GO fan page,
and found the following announcement…

Update: Pokémon CP Adjustment



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So the base stats was updated?
That is a *terrible* news!

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Fortunately,
my IV calculator was not published yet.

I Googled,
and found someone has already published
a new base stats table.

I immediately applied it to my IV calculator.

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Case #2

The other day when I was walking,
I hatched something I had never seen!

So I went to the Pokémon GO fan page again.

Update: New Pokémons Added!

Ouch!
I don’t have the data of these babies yet!

It’s not hard to Google
for the base stats of these new babies.

But I do not have their images!

I spent all my game coins
to hatch these baby Pokémons.

And, in the end,
I beg my every friend
for screenshots of baby Pokémons
that I missed.

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Lessons I Learned

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Lesson #1

If you are creating some game hacking tool
without commercial support,
you had better *not* publish it.

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When the game updates,
you'll have to update immediately.

It's a nightmare.

Lesson #2

For strong species like Dragonite,
base stats take the largest part of the CP.

Dragonite is just stronger!

Attack: 263 + IV 15 = 278
Defense: 201 + IV 15 = 216
Stamina: 182 + IV 11 = 193

The second factor
is the Pokémon level (the CPM).

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And your individual values (IV)?

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Well, it doesn’t really matter. :p

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Thank you.
Any questions?