# main

December 18, 2024

## 0.1 Import libraries

[739]:
```
from stockfish import Stockfish
from stockfish import StockfishException
import pandas as pd
import numpy as np
import re
import os
import pickle
from concurrent.futures import ThreadPoolExecutor, as_completed
from timeit import default_timer as timer
import random
import string
import matplotlib.pyplot as plt
import seaborn as sns
import chess
import chess.svg
from IPython.display import SVG, display, HTML, Image
```

## 0.2 Import dataset

[3]:
```
with open('valid_positions.txt') as f:
    pos = f.readlines()
pos1 = []
for i in range(len(pos)):
    pos1.append(re.sub('\n','', pos[i]))
dataset = pos1
```

We are using a reduced version of the original dataset, with some invalid positions excluded

## 0.3 Additional fucntions

[4]:
```
#evaluation function
def evaluation(pos, elo, depth):
    stockfish = Stockfish('stockfish_15_x64_avx2.exe')
    stockfish.set_elo_rating(elo)
    stockfish.set_depth(depth)
    stockfish.set_fen_position(pos)
```

```
    ev = stockfish.get_evaluation()
    pos = stockfish.get_top_moves(1)
    return ev, pos

def evaluationdouble(pos1, pos2, elo, depth):
    stockfish = Stockfish('stockfish_15_x64_avx2.exe')
    stockfish.set_elo_rating(elo)
    stockfish.set_depth(depth)
    stockfish.set_fen_position(pos1)
    ev1 = stockfish.get_evaluation()
    stockfish.set_fen_position(pos2)
    ev2 = stockfish.get_evaluation()
    return ev1, ev2

def show_pos(fen_list, size, space=10):
    boards = [chess.Board(fen) for fen in fen_list]
    svg_boards = [chess.svg.board(board=board, size=size) for board in boards]
    html_code = "<div style='display: inline-block; margin-right: {}px;'>{}</
 ↪div>".format(space, "</div><div style='display: inline-block; margin-right:␣
 ↪{}px;'>".format(space).join(svg_boards))
    display(HTML(html_code))
```

[5]:
```
#delta
def dif1(val1, val2):
    if abs(val1) + abs(val2) == 0:
        return 0
    else:
        return abs(val1 - val2) / (abs(val1) + abs(val2))

#epsilon
def dif2(val1, val2):
    return float(abs(val1 - val2))
```

[6]:
```
def checkcheckW(pos):
    def make_matrix(board):  # type(board) == chess.Board()
        pgn = board
        foo = []  # Final board
        pieces = pgn.split(" ", 1)[0]
        rows = pieces.split("/")
        for row in rows:
            foo2 = []  # This is the row I make
            for thing in row:
                if thing.isdigit():
                    for i in range(0, int(thing)):
                        foo2.append('.')
                else:
                    foo2.append(thing)
```

```
            foo.append(foo2)
        return foo

    whites = ['Q', 'K', 'R', 'B', 'N', 'P']
    blacks = ['q', 'k', 'r', 'b', 'n', 'p']
    a = make_matrix(pos)
    check = False
    pos = []
    for i in range(8):
        for j in range(8):
            if a[i][j] == 'K':
                pos.append(i)
                pos.append(j)
    for i in list(reversed(range(pos[1]))):
        if a[pos[0]][i] in whites or a[pos[0]][i] in list(blacks[j] for j in␣
↪[1, 3, 4, 5]):
            break
        elif a[pos[0]][i] == 'q' or a[pos[0]][i] == 'r':
            check = True
            break
    for i in list(range(pos[1] + 1, 8)):
        if a[pos[0]][i] in whites or a[pos[0]][i] in list(blacks[j] for j in␣
↪[1, 3, 4, 5]):
            break
        elif a[pos[0]][i] == 'q' or a[pos[0]][i] == 'r':
            check = True
            break
    for i in list(reversed(range(pos[0]))):
        if a[i][pos[1]] in whites or a[i][pos[1]] in list(blacks[j] for j in␣
↪[1, 3, 4, 5]):
            break
        elif a[i][pos[1]] == 'q' or a[i][pos[1]] == 'r':
            check = True
            break
    for i in list(range(pos[0] + 1, 8)):
        if a[i][pos[1]] in whites or a[i][pos[1]] in list(blacks[j] for j in␣
↪[1, 3, 4, 5]):
            break
        elif a[i][pos[1]] == 'q' or a[i][pos[1]] == 'r':
            check = True
            break
    r = 8 - np.maximum(abs(pos[0]), abs(pos[1]))
    r1 = np.minimum(abs(pos[0]), abs(pos[1]))
    r2 = np.minimum(r, r1)
    for i in list(range(1, r)):
        if a[pos[0] + i][pos[1] + i] in whites or a[pos[0] + i][pos[1] + i] in␣
↪list(blacks[j] for j in [1, 2, 4, 5]):
```

```
            break
        elif a[pos[0] + i][pos[1] + i] == 'b' or a[pos[0] + i][pos[1] + i] ==␣
↪'q':
            check = True
            break
    for i in list(range(1, r2)):
        if a[pos[0] - i][pos[1] + i] in whites or a[pos[0] - i][pos[1] + i] in␣
↪list(blacks[j] for j in [1, 2, 4, 5]):
            break
        elif a[pos[0] - i][pos[1] + i] == 'b' or a[pos[0] - i][pos[1] + i] ==␣
↪'q':
            check = True
            break
    for i in list(range(1, r2)):
        if a[pos[0] - i][pos[1] - i] in whites or a[pos[0] - i][pos[1] - i] in␣
↪list(blacks[j] for j in [1, 2, 4, 5]):
            break
        elif a[pos[0] - i][pos[1] - i] == 'b' or a[pos[0] - i][pos[1] - i] ==␣
↪'q':
            check = True
            break
    for i in list(range(1, r)):
        if a[pos[0] + i][pos[1] - i] in whites or a[pos[0] + i][pos[1] - i] in␣
↪list(blacks[j] for j in [1, 2, 4, 5]):
            break
        elif a[pos[0] + i][pos[1] - i] == 'b' or a[pos[0] + i][pos[1] - i] ==␣
↪'q':
            check = True
            break
    if pos[0] + 2 < 8 and pos[1] - 1 > 0 and a[pos[0] + 2][pos[1] - 1] == 'n':
        check = True
    if pos[0] + 2 < 8 and pos[1] + 1 < 8 and a[pos[0] + 2][pos[1] + 1] == 'n':
        check = True
    if pos[0] - 2 > 0 and pos[1] - 1 > 0 and a[pos[0] - 2][pos[1] - 1] == 'n':
        check = True
    if pos[0] - 2 > 0 and pos[1] + 1 < 8 and a[pos[0] - 2][pos[1] + 1] == 'n':
        check = True
    if pos[0] + 1 < 8 and pos[1] - 2 > 0 and a[pos[0] + 1][pos[1] - 2] == 'n':
        check = True
    if pos[0] + 1 < 8 and pos[1] + 2 < 8 and a[pos[0] + 1][pos[1] + 2] == 'n':
        check = True
    if pos[0] - 1 > 0 and pos[1] - 2 > 0 and a[pos[0] - 1][pos[1] - 2] == 'n':
        check = True
    if pos[0] - 1 > 0 and pos[1] + 2 < 8 and a[pos[0] - 1][pos[1] + 2] == 'n':
        check = True
    if pos[0] - 1 > 0 and pos[1] - 1 > 0 and a[pos[0] - 1][pos[1] - 1] == 'p':
```

```
        check = True
    if pos[0] - 1 > 0 and pos[1] + 1 < 8 and a[pos[0] - 1][pos[1] + 1] == 'p':
        check = True
    return check


def checkcheckB(pos):
    def make_matrix(board):  # type(board) == chess.Board()
        pgn = board
        foo = []  # Final board
        pieces = pgn.split(" ", 1)[0]
        rows = pieces.split("/")
        for row in rows:
            foo2 = []  # This is the row I make
            for thing in row:
                if thing.isdigit():
                    for i in range(0, int(thing)):
                        foo2.append('.')
                else:
                    foo2.append(thing)
            foo.append(foo2)
        return foo

    whites = ['Q', 'K', 'R', 'B', 'N', 'P']
    blacks = ['q', 'k', 'r', 'b', 'n', 'p']
    a = make_matrix(pos)
    check = False
    pos = []
    for i in range(8):
        for j in range(8):
            if a[i][j] == 'k':
                pos.append(i)
                pos.append(j)
    for i in list(reversed(range(pos[1]))):
        if a[pos[0]][i] in blacks or a[pos[0]][i] in list(whites[j] for j in␣
 ↪[1, 3, 4, 5]):
            break
        elif a[pos[0]][i] == 'Q' or a[pos[0]][i] == 'R':
            check = True
            break
    for i in list(range(pos[1] + 1, 8)):
        if a[pos[0]][i] in blacks or a[pos[0]][i] in list(whites[j] for j in␣
 ↪[1, 3, 4, 5]):
            break
        elif a[pos[0]][i] == 'Q' or a[pos[0]][i] == 'R':
            check = True
            break
```

```
  for i in list(reversed(range(pos[0]))):
      if a[i][pos[1]] in blacks or a[i][pos[1]] in list(whites[j] for j in␣
↪[1, 3, 4, 5]):
          break
      elif a[i][pos[1]] == 'Q' or a[i][pos[1]] == 'R':
          check = True
          break
  for i in list(range(pos[0] + 1, 8)):
      if a[i][pos[1]] in blacks or a[i][pos[1]] in list(whites[j] for j in␣
↪[1, 3, 4, 5]):
          break
      elif a[i][pos[1]] == 'Q' or a[i][pos[1]] == 'R':
          check = True
          break
  r = 8 - np.maximum(abs(pos[0]), abs(pos[1]))
  r1 = np.minimum(abs(pos[0]), abs(pos[1]))
  r2 = np.minimum(r, r1)
  for i in list(range(1, r)):
      if a[pos[0] + i][pos[1] + i] in blacks or a[pos[0] + i][pos[1] + i] in␣
↪list(whites[j] for j in [1, 2, 4, 5]):
          break
      elif a[pos[0] + i][pos[1] + i] == 'B' or a[pos[0] + i][pos[1] + i] ==␣
↪'Q':
          check = True
          break
  for i in list(range(1, r2)):
      if a[pos[0] - i][pos[1] + i] in blacks or a[pos[0] - i][pos[1] + i] in␣
↪list(whites[j] for j in [1, 2, 4, 5]):
          break
      elif a[pos[0] - i][pos[1] + i] == 'B' or a[pos[0] - i][pos[1] + i] ==␣
↪'Q':
          check = True
          break
  for i in list(range(1, r2)):
      if a[pos[0] - i][pos[1] - i] in blacks or a[pos[0] - i][pos[1] - i] in␣
↪list(whites[j] for j in [1, 2, 4, 5]):
          break
      elif a[pos[0] - i][pos[1] - i] == 'B' or a[pos[0] - i][pos[1] - i] ==␣
↪'Q':
          check = True
          break
  for i in list(range(1, r)):
      if a[pos[0] + i][pos[1] - i] in blacks or a[pos[0] + i][pos[1] - i] in␣
↪list(whites[j] for j in [1, 2, 4, 5]):
          break
```

```
        elif a[pos[0] + i][pos[1] - i] == 'B' or a[pos[0] + i][pos[1] - i] ==␣
↪'Q':
            check = True
            break
    if pos[0] + 2 < 8 and pos[1] - 1 > 0 and a[pos[0] + 2][pos[1] - 1] == 'N':
        check = True
    if pos[0] + 2 < 8 and pos[1] + 1 < 8 and a[pos[0] + 2][pos[1] + 1] == 'N':
        check = True
    if pos[0] - 2 > 0 and pos[1] - 1 > 0 and a[pos[0] - 2][pos[1] - 1] == 'N':
        check = True
    if pos[0] - 2 > 0 and pos[1] + 1 < 8 and a[pos[0] - 2][pos[1] + 1] == 'N':
        check = True
    if pos[0] + 1 < 8 and pos[1] - 2 > 0 and a[pos[0] + 1][pos[1] - 2] == 'N':
        check = True
    if pos[0] + 1 < 8 and pos[1] + 2 < 8 and a[pos[0] + 1][pos[1] + 2] == 'N':
        check = True
    if pos[0] - 1 > 0 and pos[1] - 2 > 0 and a[pos[0] - 1][pos[1] - 2] == 'N':
        check = True
    if pos[0] - 1 > 0 and pos[1] + 2 < 8 and a[pos[0] - 1][pos[1] + 2] == 'N':
        check = True
    if pos[0] - 1 > 0 and pos[1] - 1 > 0 and a[pos[0] - 1][pos[1] - 1] == 'P':
        check = True
    if pos[0] - 1 > 0 and pos[1] + 1 < 8 and a[pos[0] - 1][pos[1] + 1] == 'P':
        check = True
    return check


def bothcheck(pos):
    both = False
    if checkcheckB(pos) == True and checkcheckW(pos) == True:
        both = True
    return both
```

### 0.4 Functions to alterate positions

[7]:
```
def sim_axis(pos):
    pos_transformed = []
    col = pos[-1:]
    aux1 = pos[:-2]
    aux2 = aux1.split("/")
    aux3 = []
    for j in range(8):
        aux3.append(aux2[j][::-1])
    aux4 = '/'.join(aux3)
    pos_transformed.append(aux4)
    if col == 'w':
        pos_transformed = pos_transformed[0] + ' w'
```

```
    if col == 'b':
        pos_transformed = pos_transformed[0] + ' b'
    return pos_transformed


def sim_diag(pos):
    def Convert(string):
        list1 = []
        list1[:0] = string
        return list1

    pos_transformed = []
    colour = pos[-1:]
    aux = pos.replace('8', '11111111').replace('7', '1111111').replace('6',␣
 ↪'111111').replace('5', '11111').replace('4',
                                                                          ␣
 ↪                                    '1111').replace(
        '3', '111').replace('2', '11')
    aux2 = aux.split('/')
    for i in range(8):
        aux2[i] = Convert(aux2[i])
        aux3 = [] * 8

    for j in reversed(range(8)):
        aux4 = []
        for i in reversed(range(8)):
            aux4.append(aux2[i][j])
        aux3.append(aux4)
    for i in reversed(range(8)):
        aux3[i] = "".join(aux3[i])
    pos_transformed = "/".join(aux3)
    if colour == 'b':
        pos_transformed = pos_transformed + ' b'
    else:
        pos_transformed = pos_transformed + ' w'
    pos_transformed = pos_transformed.replace('11111111', '8').
 ↪replace('1111111', '7').replace('111111', '6').replace(
        '11111', '5').replace('1111', '4').replace('111', '3').replace('11',␣
 ↪'2')

    return pos_transformed


def sim_mirror(pos):
    pos_transformed = []
    colour = pos[-1:]
    aux1 = pos[:-2]
```

```
    aux2 = aux1.swapcase()
    aux3 = aux2.split("/")
    aux4 = []
    for j in reversed(aux3):
        aux4.append(j)
        aux5 = '/'.join(aux4)
    pos_transformed.append(aux5)
    if colour == 'b':
        pos_transformed = pos_transformed[0] + ' w'
    else:
        pos_transformed = pos_transformed[0] + ' b'
    return pos_transformed


def replace(pos):
    if pos.count('B') > 0 & pos.count('R') > 0:
        n = random.random()
        if n > 0.5:
            aux = pos.replace('R', 'Q', 1)
        else:
            aux = pos.replace('B', 'Q', 1)
    elif pos.count('B') > 0 & pos.count('R') == 0:
        aux = pos.replace('B', 'Q', 1)
    elif pos.count('R') > 0 & pos.count('B') == 0:
        aux = pos.replace('R', 'Q', 1)
    else:
        aux = pos
    return aux
```

### 0.5 MRs

[726]:
```
#for sim_axis and sim_diag
def MR_equi(o1, o2, delta, epsilon):
    final = False
    if o1.get('type') != o2.get('type'):
        final = False
    elif o1.get('type') == o2.get('type') == 'mate' and o1.get('value') != o2.
 ↪get('value'):
        final = False
    elif o1.get('type') == o2.get('type') == 'cp' and dif1(o1.get('value'), o2.
 ↪get('value')) > delta and dif2(
            o1.get('value'), o2.get('value')) >= epsilon:
        final = False
    else:
        final = True
    return final
```

```
#for sim_mirror
def MR_mirror(o1, o2, delta, epsilon):
    final = False
    if o1.get('type') != o2.get('type'):
        final = False
    elif o1.get('type') == o2.get('type') == 'mate' and o1.get('value') != (-1␣
 ↪* o2.get('value')):
    #elif o1.get('type') == o2.get('type') == 'mate' and o1.get('value') * (-1␣
 ↪* o2.get('value'))<0:
        final = False
    elif o1.get('type') == o2.get('type') == 'cp' and dif1(o1.get('value'), (-1␣
 ↪* o2.get('value'))) > delta and dif2(
            o1.get('value'), (-1 * o2.get('value'))) >= epsilon:
        final = False
    else:
        final = True
    return final

#for replace
def MR_better_original(o1,o2,delta,epsilon):
    final = bool()
    if o1.get('type') != o2.get('type') and o2.get('type') != 'mate':
        final = False
    elif o1.get('type') == o2.get('type') == 'mate' and o1.get('value') < o2.
 ↪get('value') and o1.get('value') > 0:
        final = False
    elif o1.get('type') == o2.get('type') == 'mate' and o1.get('value') > o2.
 ↪get('value') and o1.get('value') < 0:
        final = False
    elif o1.get('type') == o2.get('type') == 'cp' and o1.get('value') > o2.
 ↪get('value') and dif1(o1.get('value'),o2.get('value')) > delta and dif2(o1.
 ↪get('value'),o2.get('value')) >= epsilon:
        final = False
    else:
        final = True
    return final

#when using the evaluation after the best move
def MR_first(o1, o2, delta, epsilon):
    final = False
    if o1[0].get('Mate') != o2[0].get('Mate'):
        final = False
    elif o1[0].get('Mate') == o2[0].get('Mate') == None and dif1(o1[0].
 ↪get('Centipawn'),
                                                                 o2[0].
 ↪get('Centipawn')) > delta and dif2(
```

```
            o1[0].get('Centipawn'), o2[0].get('Centipawn')) >= epsilon:
        final = False
    else:
        final = True
    return final
```

### 0.5.1 Problem with the original MR_better : example

[9]:
```
pos = '1B1n1r2/8/8/1n5b/3r4/8/5k2/2K5'
pos2 = replace(pos)
ev1 = evaluation(pos,5000,10)[0]
ev2 = evaluation (pos2, 5000, 10)[0]

print(ev1, '\n', ev2)
```

```
{'type': 'mate', 'value': -10}
 {'type': 'cp', 'value': -824}
```

Before replace –> mate in 10 for Black After replace –> advantage of 824 centipawns for Black

The evaluation got better for White, which should meet the MR requirements but:

[10]:
```
print(MR_better_original(ev1,ev2,1,100))
```

```
False
```

It seems that some conditions are incorrect in the original MR_better function, so we modified it as follows:

[11]:
```
def MR_better(o1, o2, delta, epsilon):
    final = False
    # knowing that we're upgrading white pieces (always)
    # if we switch from diff in centipawns to mate for Black --> False
    if o1.get('type') == 'cp' and o2.get('type') == 'mate' and o2.get('value')␣
 ↪< 0:
        final = False
    # if we switch from mate to diff in centipawns for White --> False
    elif o1.get('type') == 'mate' and o2.get('type') == 'cp' and o1.
 ↪get('value') > 0:
        final = False
    # ex : from #7 to #9 --> False
    elif o1.get('type') == o2.get('type') == 'mate' and o2.get('value') > o1.
 ↪get('value') > 0:
        final = False
    # ex : from #-9 to #-7 --> False
    elif o1.get('type') == o2.get('type') == 'mate' and 0 > o2.get('value') >␣
 ↪o1.get('value'):
        final = False
    # ex : from #5 to #-5 --> False
```

```
    elif o1.get('type') == o2.get('type') == 'mate' and o1.get('value') > 0 >␣
↪o2.get('value'):
        final = False
    # if centipawns diff for both evaluations, will depend on thresholds
    elif o1.get('type') == o2.get('type') == 'cp' and o1.get('value') > o2.
↪get('value') and dif1(o1.get('value'),
                                                                          ␣
↪                  o2.get('value')) > delta and dif2(
            o1.get('value'), o2.get('value')) >= epsilon:
        final = False
    else:
        final = True
    return final
```

## 0.6 Main functions

### 0.6.1 Function for mass evaluations

[12]:
```
def main(dataset, elo, depth, type):
    global threadsfinis
    global threadstotaux
    pos1 = []
    pos2 = []
    results1 = []
    results2 = []
    start = timer()
    index = []
    if type == 0:
        for i in range(len(dataset)):
            if bothcheck(dataset[i]) == False and␣
↪bothcheck(sim_mirror(dataset[i])) == False:
                if i%5==0:
                    print(i)
                try:
                    ev1 = evaluation(dataset[i], elo, depth)[0]
                    ev2 = evaluation(sim_mirror(dataset[i]), elo, depth)[0]
                    pos1.append(dataset[i])  ## adding original position to␣
↪dataframe
                    pos2.append(sim_mirror(dataset[i]))  ## adding transformed␣
↪position to dataframe
                    results1.append(ev1)  ## adding evaluation of original␣
↪position to dataframe
                    results2.append(ev2)  ## adding evaluation of transformed␣
↪position to dataframe
                    index.append(i)  ## adding index to dataframe
                except StockfishException:
                    pass
```

```
  elif type == 1:
      for i in range(len(dataset)):
          if bothcheck(dataset[i]) == False and␣
↪bothcheck(sim_axis(dataset[i])) == False:
              if i%5==0:
                  print(i)
              try:
                  ev1 = evaluation(dataset[i], elo, depth)[0]
                  ev2 = evaluation(sim_axis(dataset[i]), elo, depth)[0]
                  pos1.append(dataset[i])  ## adding original position to␣
↪dataframe
                  pos2.append(sim_axis(dataset[i]))  ## adding transformed␣
↪position to dataframe
                  results1.append(ev1)  ## adding evaluation of original␣
↪position to dataframe
                  results2.append(ev2)  ## adding evaluation of transformed␣
↪position to dataframe
                  index.append(i)  ## adding index to dataframe
              except StockfishException:
                  pass
  elif type == 2:
      for i in range(len(dataset)):
          #ignoring positions with pawns
          if bothcheck(dataset[i]) == False and␣
↪bothcheck(sim_diag(dataset[i])) == False and 'p' not in dataset[
              i] and 'P' not in dataset[i]:
              if i%5==0:
                  print(i)
              try:
                  ev1 = evaluation(dataset[i], elo, depth)[0]
                  ev2 = evaluation(sim_diag(dataset[i]), elo, depth)[0]
                  pos1.append(dataset[i])  ## adding original position to␣
↪dataframe
                  pos2.append(sim_diag(dataset[i]))  ## adding transformed␣
↪position to dataframe
                  results1.append(ev1)  ## adding evaluation of original␣
↪position to dataframe
                  results2.append(ev2)  ## adding evaluation of transformed␣
↪position to dataframe
                  index.append(i)  ## adding index to dataframe
              except StockfishException:
                  pass
  elif type == 3:
      for i in range(len(dataset)):
          #ignoring positions without white rooks or bishops
```

```
            if bothcheck(dataset[i]) == False and␣
↪bothcheck(replace(dataset[i])) == False and (
                    'B' in dataset[i] or 'R' in dataset[i]):
                if i%5==0:
                    print(i)
                try:
                    ev1 = evaluation(dataset[i], elo, depth)[0]
                    ev2 = evaluation(replace(dataset[i]), elo, depth)[0]
                    pos1.append(dataset[i])  ## adding original position to␣
↪dataframe
                    pos2.append(replace(dataset[i]))  ## adding transformed␣
↪position to dataframe
                    results1.append(ev1)  ## adding evaluation of original␣
↪position to dataframe
                    results2.append(ev2)  ## adding evaluation of transformed␣
↪position to dataframe
                    index.append(i)  ## adding index to dataframe
                except StockfishException:
                    pass

    elif type == 4:
        for i in range(len(dataset)):
            if bothcheck(dataset[i]) == False and␣
↪bothcheck(sim_axis(dataset[i])) == False:
                if i%5==0:
                    print(i)
                try:
                    ev1 = evaluation(dataset[i], elo, depth)[1]
                    ev2 = evaluation(sim_axis(dataset[i]), elo, depth)[1]
                    # ajout d'un len à la fin parce que souci si on essaie de␣
↪faire jouer un coup sur une position où ça n'est pas possible (mat, pat)
                    if len(ev1) != 0 and len(ev2) != 0:
                        # MR.
↪append(MR_first(evaluation(dataset[i],elo,depth)[1],evaluation(sim_axis(dataset[i]),␣
↪elo, depth)[1], delta, epsilon)) ## adding MR to dataframe
                        pos1.append(dataset[i])  ## adding original position to␣
↪dataframe
                        pos2.append(sim_axis(dataset[i]))  ## adding␣
↪transformed position to dataframe
                        results1.append(ev1)  ## adding evaluation of original␣
↪position to dataframe
                        results2.append(ev2)  ## adding evaluation of␣
↪transformed position to dataframe
                        index.append(i)  ## adding index to dataframe
                except StockfishException:
                    pass
```

```
    d = {'index': index, 'pos1': pos1, 'evaluation pos1': results1, 'pos2':␣
↪pos2, 'evaluation pos2': results2}
    df = pd.DataFrame(data=d)  ## creating dataframe

    # print(timer()-start)
    return df
```

### 0.6.2 Function for mass MR checks

[755]:
```
def MR(df, type, delta, epsilon):
    ev1s = df["evaluation pos1"]
    ev2s = df["evaluation pos2"]
    MRs = []
    if type == 0:
        for k in range(len(ev1s)):
            MRs.append(MR_mirror(ev1s[k], ev2s[k], delta, epsilon))
    if type == 1 or type == 2:
        for k in range(len(ev1s)):
            MRs.append(MR_equi(ev1s[k], ev2s[k], delta, epsilon))
    if type == 3:
        for k in range(len(ev1s)):
            MRs.append(MR_better(ev1s[k], ev2s[k], delta, epsilon))
    if type == 6:
        for k in range(len(ev1s)):
            MRs.append(MR_better_original(ev1s[k], ev2s[k], delta, epsilon))
    if type == 4:
        for k in range(len(ev1s)):
            MRs.append(MR_first(ev1s[k], ev2s[k], delta, epsilon))
    falses = trues = 0
    for k in range(len(MRs)):
        if MRs[k]:
            trues += 1
        else:
            falses += 1
    #print("MR valides : ", trues, "; MR invalides : ", falses, "; Ratio : ",␣
↪trues / (trues + falses) * 100, "%")
    return trues / (trues + falses) * 100
```

### 0.6.3 Function for grids

[756]:
```
deltas = [0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5]
epsilons = [0, 5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100]

def tests(evas, typent, d, add='',size1 = 100):
    if typent==5:
        type = 1
```

```
    else:
        type = typent
    results_grid = []

    for delta in deltas:
        delta_results = []

        for epsilon in epsilons:
            result = 100 - MR(evas, type, delta, epsilon)

            delta_results.append(result)

        results_grid.append(delta_results)

    df_results = pd.DataFrame(results_grid, index=deltas, columns=epsilons)

    plt.figure(figsize=(10*size1//100, 6*size1//100))
    sns.heatmap(df_results, cmap='RdYlGn_r', annot=True, fmt=".2f",␣
↪cbar_kws={'label': 'Valeurs'},annot_kws={"size": 10*size1//100})
    typent = ["sim_mirror", "sim_axis", "sim_diag", "replace",␣
↪"best_move","SF15 vs SF16","replace_mr_og"][typent]

    label = 'MR violation rate, ' + typent + ', depth=' + str(d) + add

    plt.title(label)
    plt.xlabel('Epsilons')
    plt.ylabel('Deltas')
    plt.plot()
```

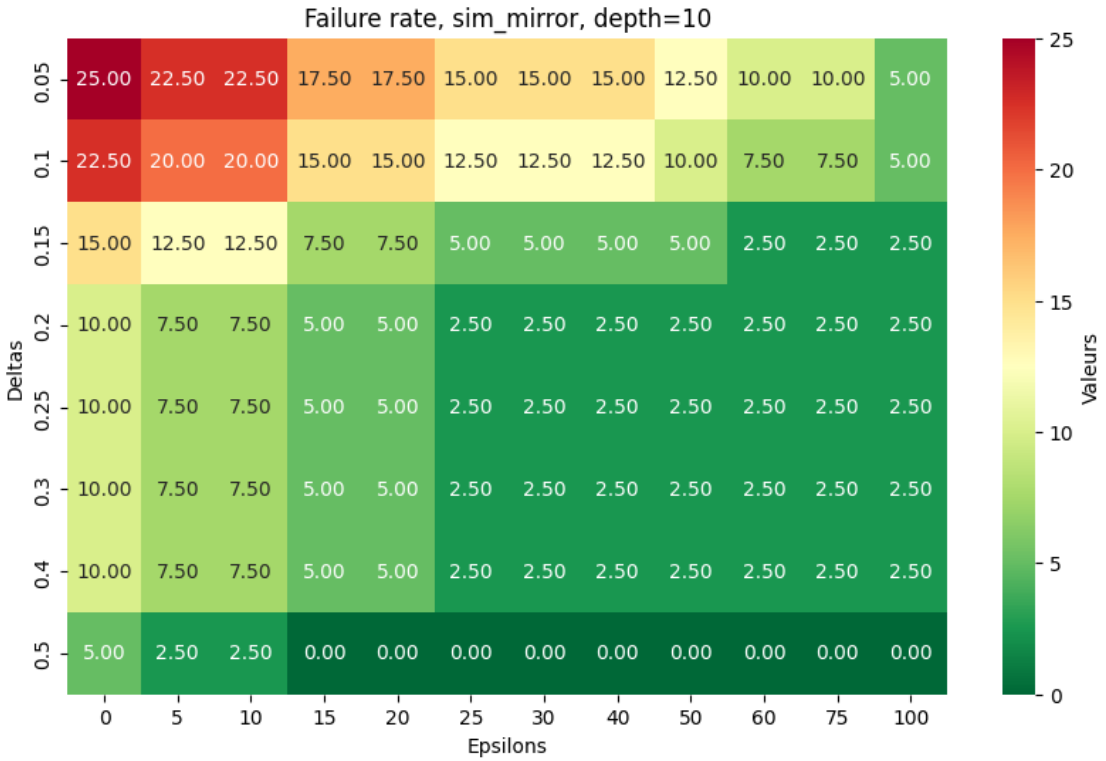
### 0.7 Application of main functions

An example with the first 40 positions of our dataset.

[15]:
```
evas = main(dataset[0:40], 4000, 10,0)
#last parameter --> type;
#0 : mirror,
#1 : sim_axis,
#2 : sim_diag,
#3 : better,
#4 : first
tests(evas,0,10)
```

```
0
5
10
15
20
25
```

30
35



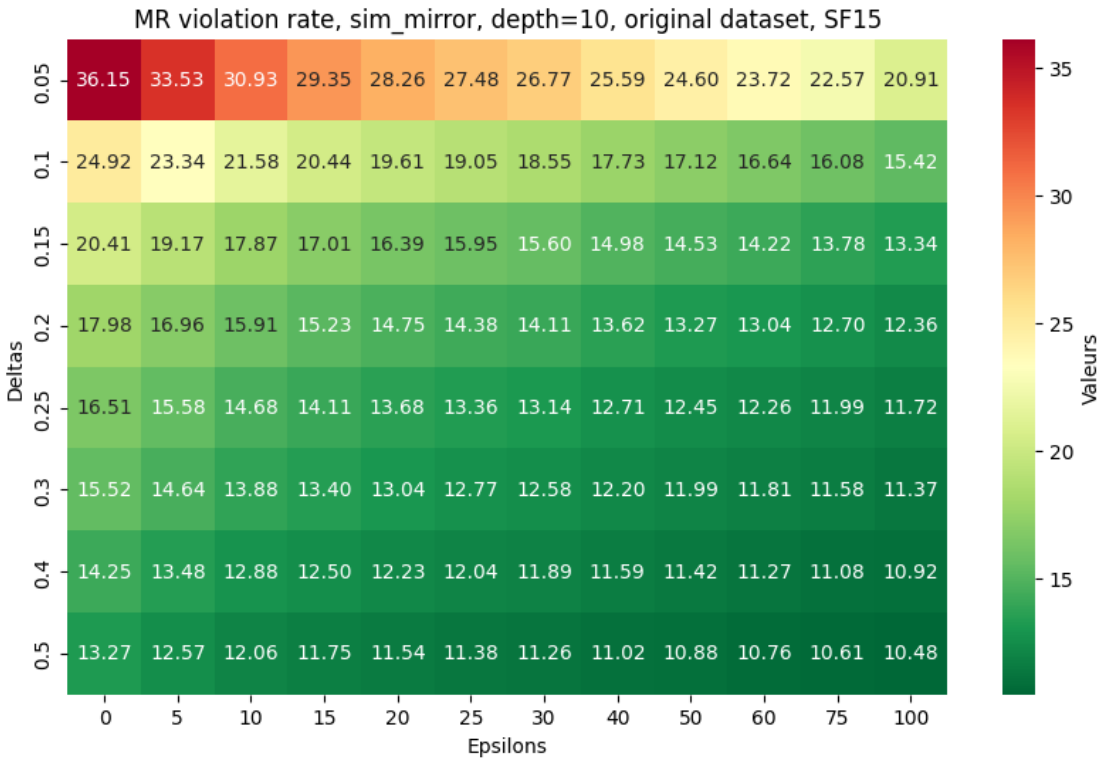

## 0.8 Observations

### 0.8.1 sim_mirror

Evaluations are stored in pickle files. #### depth = 10, entire dataset (Link V16)

Showing at first the grid we got ourselves.

[730]:
```
path = os.path.join('sim_mirror_d=10','evaluations50000_sim_mirror_d_10.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_mirror_d_10 = pickle.load(file)

tests(evaluations50000_sim_mirror_d_10,0,10, ', original dataset, SF15')
```




Here is the grid from the article.

[751]:
```
from IPython.display import display, Image

display(Image(filename='originalmirror10.png',width=900,height=900))
```

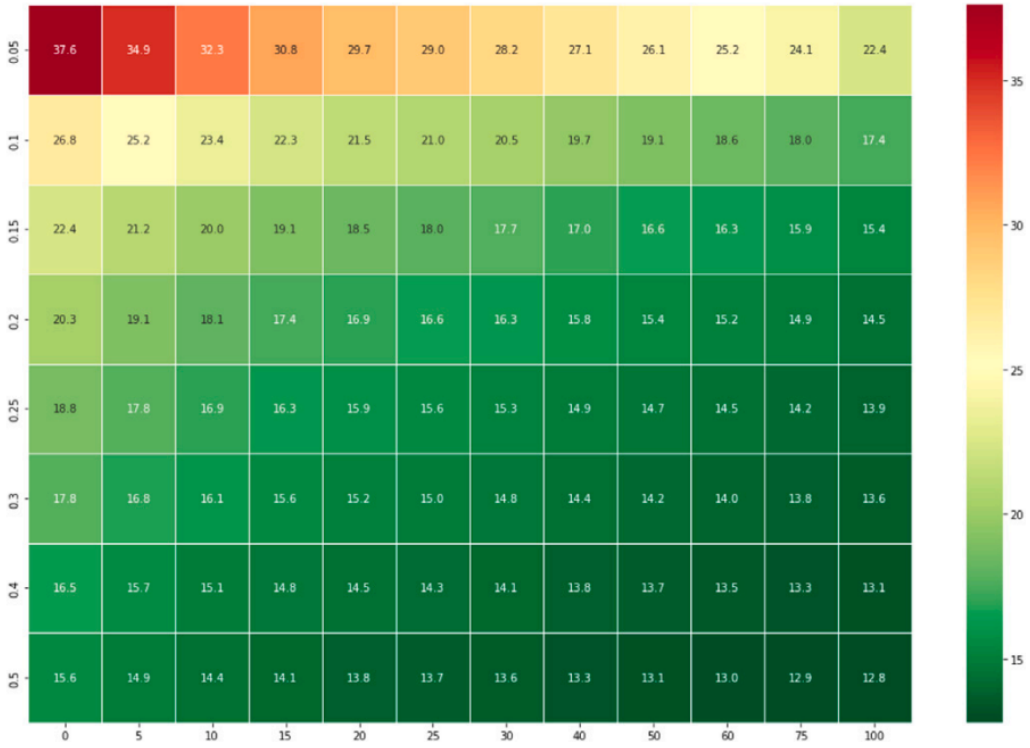
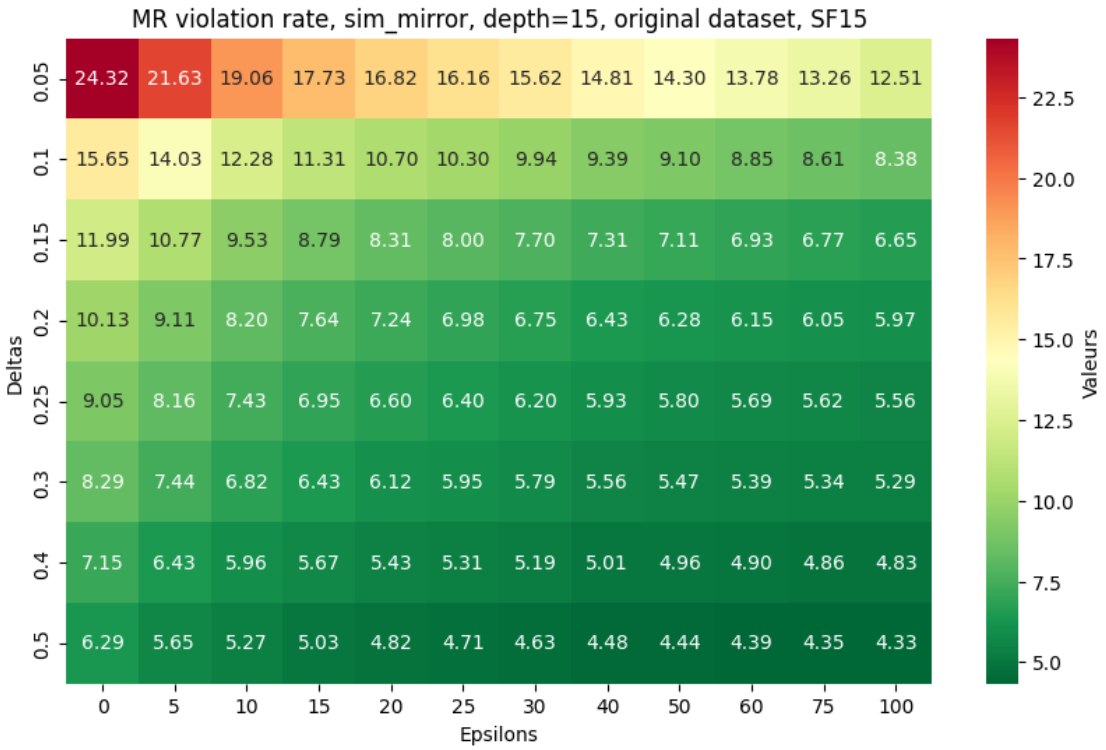



**Fig. 8.** Percentage of problems detected by $\mathrm{MR}_{\mathtt{mirror}}$. $x$-axis represents $\epsilon$ value and $y$-axis represents $\delta$ value.

The results are really similar, the minor differences we observe could be to system differences. Same comment for the other mutations, replace() aside.

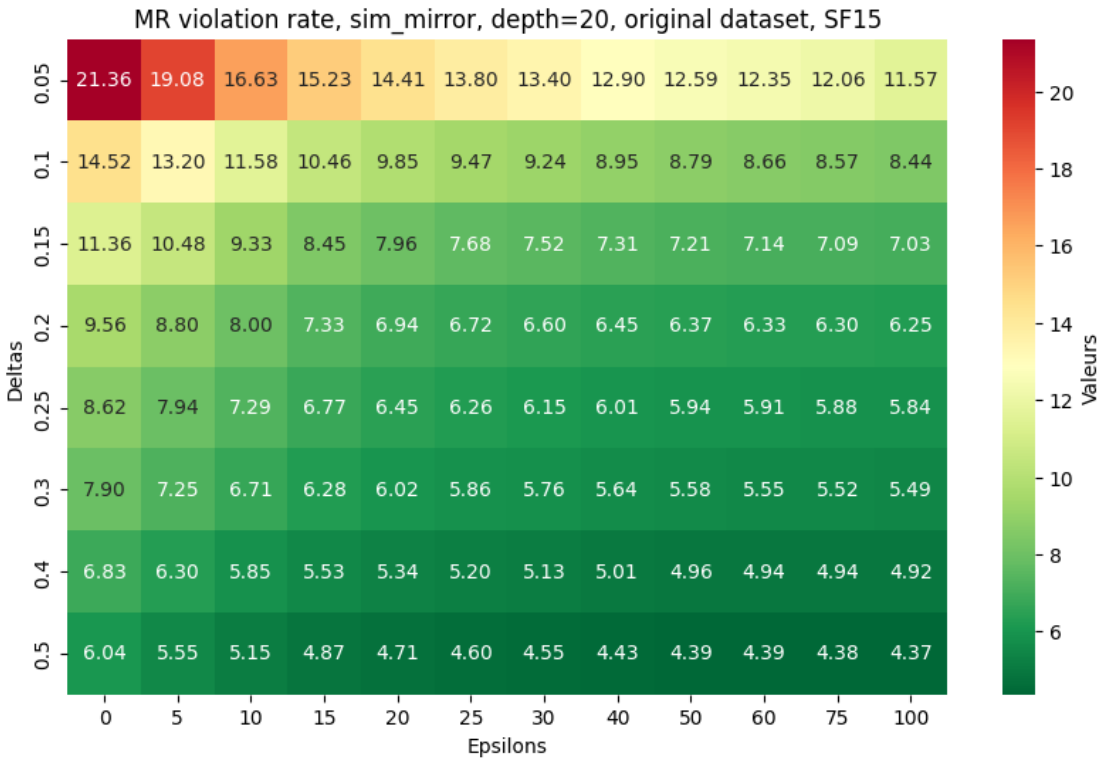
**depth = 15, entire dataset**

[456]:
```
path = os.path.join('sim_mirror_d=15','evaluations50000_sim_mirror_d_15.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_mirror_d_15 = pickle.load(file)

tests(evaluations50000_sim_mirror_d_15,0,15, ', original dataset, SF15')
```




**depth = 20, entire dataset (Link V16)**

[725]:
```
path = os.path.join('sim_mirror_d=20','evaluations50000_sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_mirror_d_20 = pickle.load(file)

tests(evaluations50000_sim_mirror_d_20,0,20, ', original dataset, SF15')
```




We can observe that despite increasing the depth, the results are not getting better, we could even say that it is worsening. We also observed that with each position mutations. We decided to check positions that had important deviations on depth 10 (that we found by setting important thresholds) when evaluating their equivalent counterpart. After checking many positions, we found that big differences are often observed when the advante for one side is big, in centipawns or when it is not far from a mate. Examples :

[19]:
```
pos1 = '1B4R1/7B/8/2K3n1/8/7k/R1r5/1B6 w'
pos2 = '1N5k/3Kb2q/1NP3p1/1R4B1/3R4/1B6/8/n3Q3 w'
show_pos([pos1,pos2],300)

print("pos1 : ",evaluationdouble(pos1,sim_mirror(pos1),50000,10))
print("pos2 : ",evaluationdouble(pos2,sim_axis(pos2),50000,10))
```

```
<IPython.core.display.HTML object>

pos1 :  ({'type': 'mate', 'value': 9}, {'type': 'cp', 'value': -2101})
pos2 :  ({'type': 'cp', 'value': 7305}, {'type': 'cp', 'value': 2850})
```

It seems that Stockfish starts to return high values when the positions are not far from a mate. If we increase the depth, the second evaluation also indicate a mate:

[20]:
```
print("pos1 : ",evaluationdouble(pos1,sim_mirror(pos1),50000,15))
print("pos2 : ",evaluationdouble(pos2,sim_axis(pos2),50000,15))
```

```
pos1 :  ({'type': 'mate', 'value': 6}, {'type': 'mate', 'value': -5})
pos2 :  ({'type': 'mate', 'value': 8}, {'type': 'mate', 'value': 7})
```

Reaching a certain depth, Stockfish returns the same values for both original and mutated positions.

[21]:
```
print("pos1 : ",evaluationdouble(pos1,sim_mirror(pos1),50000,20))
print("pos2 : ",evaluationdouble(pos2,sim_axis(pos2),50000,20))
```

```
pos1 :  ({'type': 'mate', 'value': 5}, {'type': 'mate', 'value': -5})
pos2 :  ({'type': 'mate', 'value': 7}, {'type': 'mate', 'value': 7})
```

We have to notice that MRs will always detect a problem if the evaluations' types are different OR if they are a mate for both positions but their values are not exactly the same. It is therefore strange to observe that increasing the depth does not improve the rate of respected MRs, but it could explain why that much problem are detected. We then checked the biggest deviations with depth 15.

[22]:
```
pos3 = '2N5/3k4/8/3B4/1K6/5n1r/8/4r3 b'
show_pos([pos3],300)
ev10 = evaluationdouble(pos3,sim_diag(pos3),50000,10)
print("pos3, d=10 : ", ev10, " - ", MR_equi(ev10[0],ev10[1],0.25,20))
ev15 = evaluationdouble(pos3,sim_diag(pos3),50000,15)
print("pos3, d=15 : ", ev15, " - ", MR_equi(ev15[0],ev15[1],0.25,20))
ev20 = evaluationdouble(pos3,sim_diag(pos3),50000,20)
print("pos3, d=20 : ", ev20, " - ", MR_equi(ev20[0],ev20[1],0.25,20))
ev25 = evaluationdouble(pos3,sim_diag(pos3),50000,25)
print("pos3, d=25 : ", ev25, " - ", MR_equi(ev25[0],ev25[1],0.25,20))
ev30 = evaluationdouble(pos3,sim_diag(pos3),50000,30)
print("pos3, d=30 : ", ev30, " - ", MR_equi(ev30[0],ev30[1],0.25,20))
```

```
<IPython.core.display.HTML object>
```

```
pos3, d=10 :  ({'type': 'cp', 'value': -1088}, {'type': 'cp', 'value': -1114})
-  True
pos3, d=15 :  ({'type': 'cp', 'value': -5972}, {'type': 'cp', 'value': -1543})
-  False
pos3, d=20 :  ({'type': 'mate', 'value': -11}, {'type': 'mate', 'value': -18})
-  False
pos3, d=25 :  ({'type': 'mate', 'value': -9}, {'type': 'mate', 'value': -12})  -
False
pos3, d=30 :  ({'type': 'mate', 'value': -9}, {'type': 'mate', 'value': -9})  -
True
```

As we can see, positions with a big advantage for a side can have no problems when we use a low depth, then show big deviations when Stockfish starts to find a mate thanks to an increase in depth, and then converge when increasing the depth even more. That could explain why increasing the depth doesn't improbe our results, since the large majority of the positions in our dataset are random positions, many of them have a strange and unlikely arrangement of pieces, often leading to an overwhelming advantage for a side. In the first time, we consequently decided to split positions where a mate is detected and positions where the difference is in centipawns.

### Additional function

[23]:
```
def split_mate_cp(evaluations):
    pos1s_mate = []
    pos2s_mate = []
    ev1s_mate = []
    ev2s_mate = []
    indexy_mate = []
    pos1s_cp = []
    pos2s_cp = []
    ev1s_cp = []
    ev2s_cp = []
    indexy_cp = []
    index_cp = 0
    index_mate = 0
    for index, eva in evaluations.iterrows():
        if type(eva['evaluation pos1'])==list:
            if eva['evaluation pos1'][0].get('Mate')!=None or eva['evaluation␣
↪pos2'][0].get('type')!=None:
                indexy_mate.append(index_mate)
                index_mate+=1
                pos1s_mate.append(eva['pos1'])
                pos2s_mate.append(eva['pos2'])
                ev1s_mate.append(eva['evaluation pos1'])
                ev2s_mate.append(eva['evaluation pos2'])
            else:
                indexy_cp.append(index_mate)
                index_cp += 1
                pos1s_cp.append(eva['pos1'])
                pos2s_cp.append(eva['pos2'])
                ev1s_cp.append(eva['evaluation pos1'])
                ev2s_cp.append(eva['evaluation pos2'])
        elif eva['evaluation pos1'].get('type')=='mate' or eva['evaluation␣
↪pos2'].get('type')=='mate':
            indexy_mate.append(index_mate)
            index_mate+=1
            pos1s_mate.append(eva['pos1'])
            pos2s_mate.append(eva['pos2'])
            ev1s_mate.append(eva['evaluation pos1'])
            ev2s_mate.append(eva['evaluation pos2'])
        else:
            indexy_cp.append(index_mate)
            index_cp += 1
            pos1s_cp.append(eva['pos1'])
            pos2s_cp.append(eva['pos2'])
            ev1s_cp.append(eva['evaluation pos1'])
            ev2s_cp.append(eva['evaluation pos2'])
```

```
    dmate = {'index': indexy_mate, 'pos1': pos1s_mate, 'evaluation pos1':␣
↪ev1s_mate,
             'pos2': pos2s_mate, 'evaluation pos2': ev2s_mate}
    dcp = {'index': indexy_cp, 'pos1': pos1s_cp, 'evaluation pos1': ev1s_cp,
             'pos2': pos2s_cp, 'evaluation pos2': ev2s_cp}
    mate_evas = pd.DataFrame(data=dmate)
    cp_evas = pd.DataFrame(data=dcp)
    return cp_evas, mate_evas
```

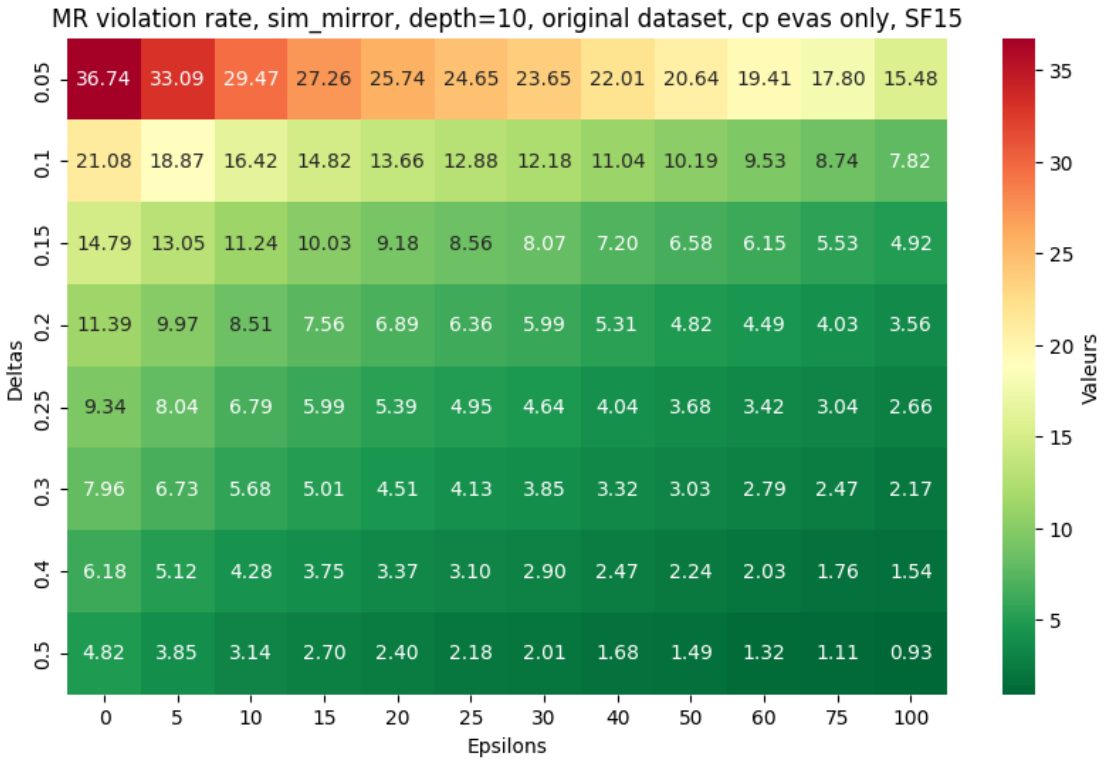
**depth = 10, splitting (Link V16)** We check the proportion of mate, and print the grids corresponding to the evaluations with a centipawns difference, then the ones with a mate, even though mate positions won't be affected by thresholds.

[24]:
```
print("Mates proportion : ",␣
↪len(split_mate_cp(evaluations50000_sim_mirror_d_10)[1])/
↪(len(split_mate_cp(evaluations50000_sim_mirror_d_10)[0])+len(split_mate_cp(evaluations50000
```

```
Mates proportion :  0.283332682622106
```

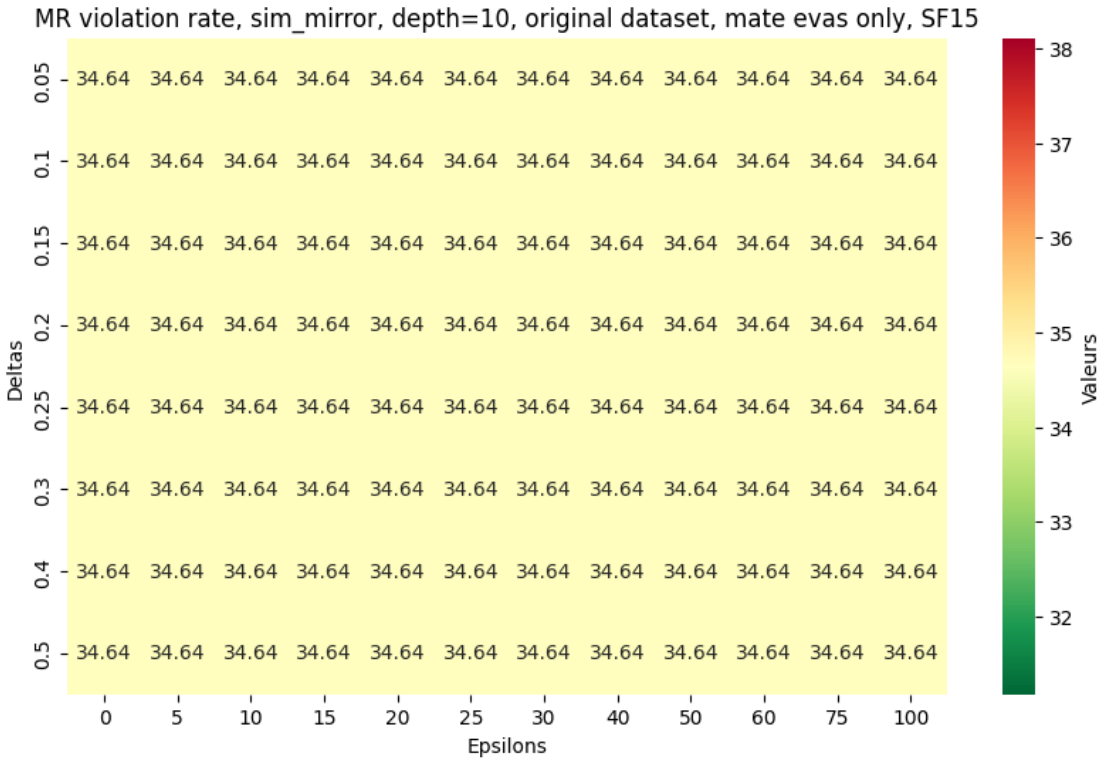
**Evaluations with a difference in centipawns**

[764]:
```
tests(split_mate_cp(evaluations50000_sim_mirror_d_10)[0],0,10, ', original␣
↪dataset, cp evas only, SF15')
```



### Evaluations with a mate

[763]:
```
tests(split_mate_cp(evaluations50000_sim_mirror_d_10)[1],0,10, ', original␣
↪dataset, mate evas only, SF15')
```




As we said, mate positions are not affected by thresholds. Since 30.43% of the mate positions have problems detected by MRs, regardless of the thresholds every grid square sees its value affected by a 30.43% of failure rate with a weight of 26.6%. If we check only the positions with a difference in centipawns, we can see that many squares of the grid have now a way lower value than before.

Note : as the MRs were designed by the original article, MRs are violated if the type is mate and value isn't exactly the same after mutation. Actually on these positions, there is no case where both evaluations show a mate but indicate values with an opposite sign.

Now we'll try to increase the depth.

### depth = 15, splitting

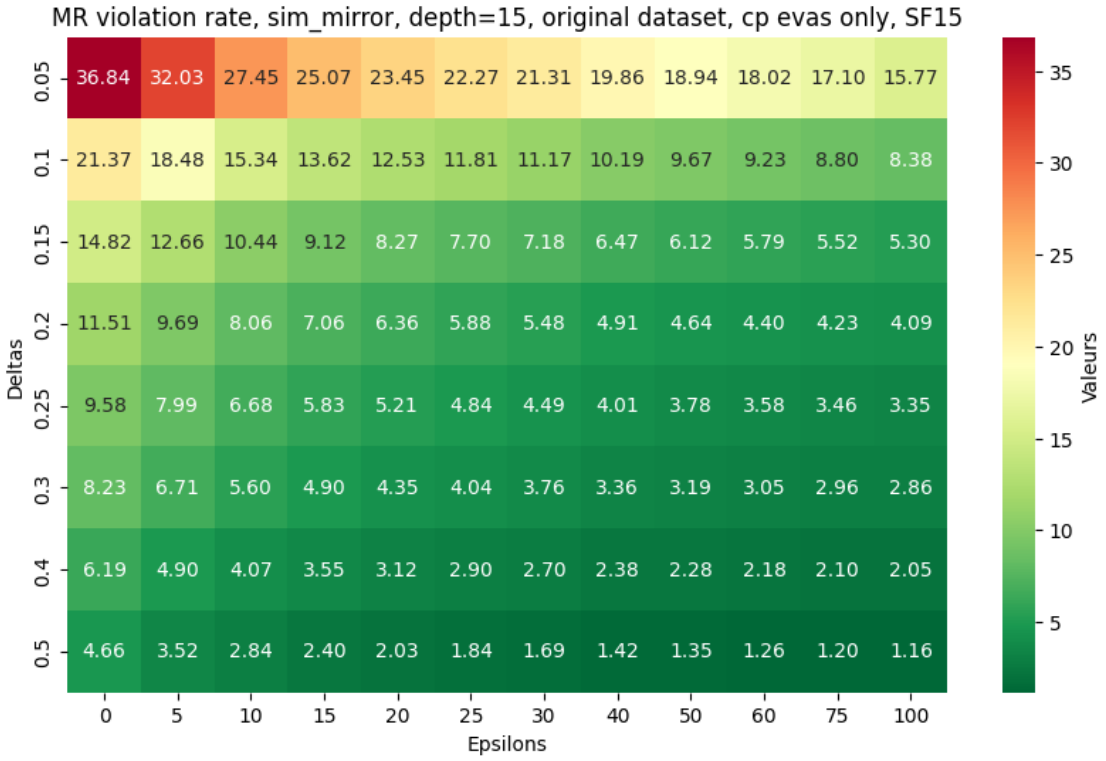
[27]:
```
print("Mates proportion : ",␣
↪len(split_mate_cp(evaluations50000_sim_mirror_d_15)[1])/
↪(len(split_mate_cp(evaluations50000_sim_mirror_d_15)[0])+len(split_mate_cp(evaluations50000
```

```
Mates proportion :  0.4397500976181179
```

The mates proportion became higher, which may be the reason why increasing the depth was not improving our results.

**Evaluations with a difference in centipawns**

[460]:
```
tests(split_mate_cp(evaluations50000_sim_mirror_d_15)[0],0,15, ', original␣
↪dataset, cp evas only, SF15')
```




**Evaluations with a mate**

[29]:
```
print('Mates failure rate :␣
↪',100-MR(split_mate_cp(evaluations50000_sim_mirror_d_15)[1],0,1,1),'%')
```

```
Mates failure rate :  37.79968034096963 %
```

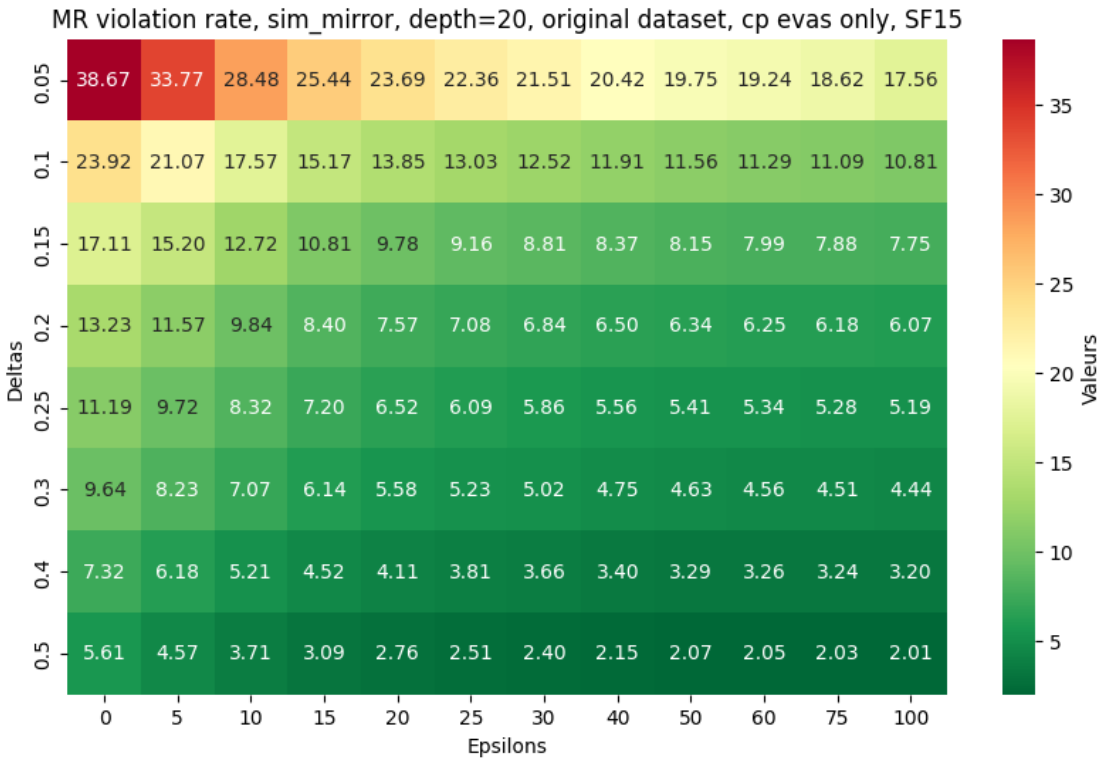
**depth = 20, splitting (Link V16)**

[30]:
```
print("Mates proportion : ",␣
↪len(split_mate_cp(evaluations50000_sim_mirror_d_20)[1])/
↪(len(split_mate_cp(evaluations50000_sim_mirror_d_20)[0])+len(split_mate_cp(evaluations50000
```

```
Mates proportion :  0.5365958612056488
```

**Evaluations with a difference in centipawns**

[461]:
```
tests(split_mate_cp(evaluations50000_sim_mirror_d_20)[0],0,20, ', original␣
↪dataset, cp evas only, SF15')
```




### Evaluations with a mate

[32]:
```
print('Mates failure rate :␣
↪',100-MR(split_mate_cp(evaluations50000_sim_mirror_d_20)[1],0,1,1),'%')
```

```
Mates failure rate :  34.27863235401327 %
```

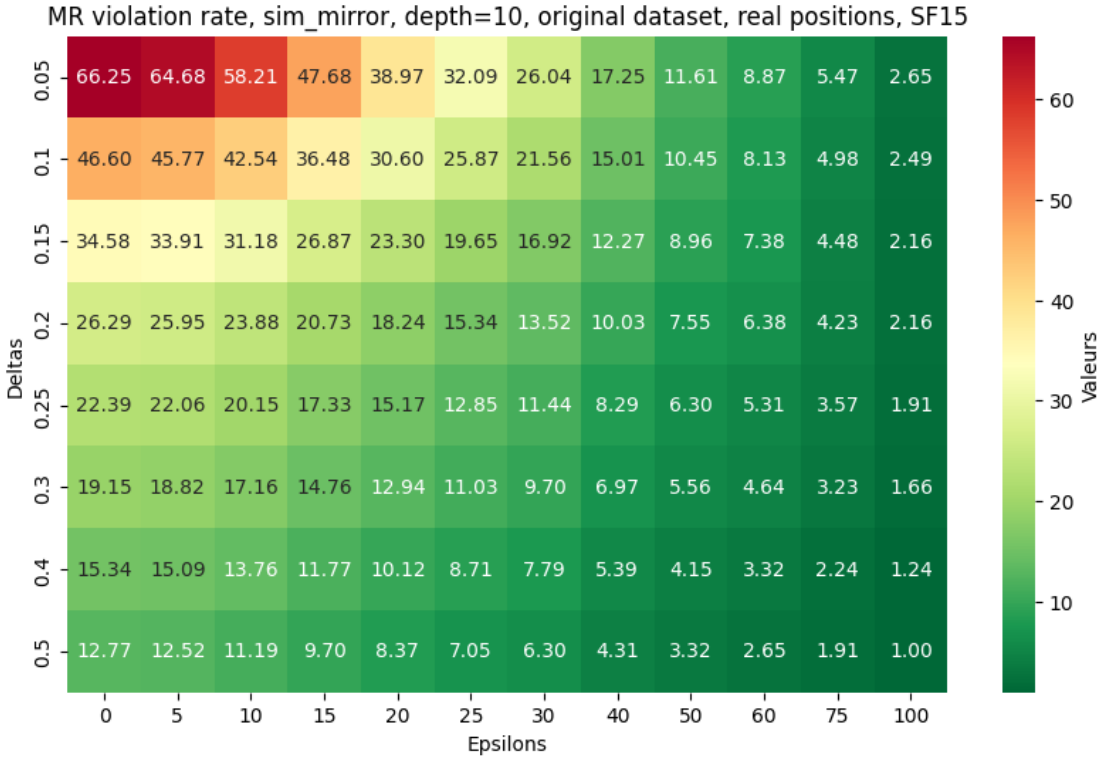
Increasing the depth did not improve our results, now we will make the grid for only the positions that were taken from real games. These positions are the 1234 last ones in our dataset.

### depth = 10, real positions (Link V16)

[33]:
```
#function to get real positions
def real_positions(evas):
    real = []
    real2 = []
    indexy = []
    ev1s = []
    ev2s = []
    index = 0
    real_pos = dataset[24768:]
    #indexent2 = 0
    for indexent, eva in evas.iterrows():
        for pos in real_pos:
            if eva['pos1'] == pos and eva['pos1'] not in real:
```

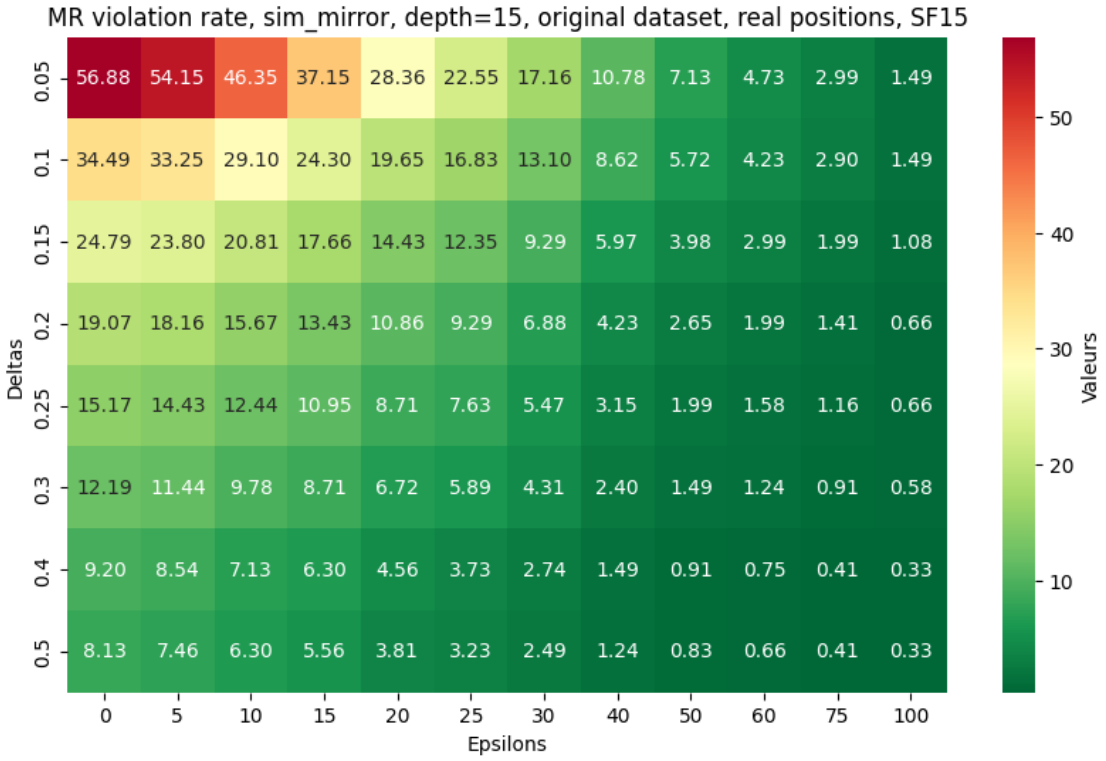
```
                #print(indexent - indexent2, index)
                #indexent2 = indexent
                indexy.append(index)
                index+=1
                real.append(eva['pos1'])
                real2.append(eva['pos2'])
                ev1s.append(eva['evaluation pos1'])
                ev2s.append(eva['evaluation pos2'])
    d = {'index': indexy, 'pos1': real, 'evaluation pos1': ev1s,
             'pos2': real2, 'evaluation pos2': ev2s}
    df = pd.DataFrame(data=d)
    return df
```

[462]:
```
evaluations50000_sim_mirror_d_10_real = real_positions(evaluations50000_sim_mirror_d_10[24000:])
evaluations50000_sim_mirror_d_10_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_sim_mirror_d_10_real,0,10, ', original dataset, real positions, SF15')
```




**depth = 15, real positions**

[463]:
```
evaluations50000_sim_mirror_d_15_real =␣
 ↪real_positions(evaluations50000_sim_mirror_d_15[24000:])
evaluations50000_sim_mirror_d_15_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_sim_mirror_d_15_real,0,15, ', original dataset, real␣
 ↪positions, SF15')
```




### depth = 20, real positions (Link V16)

[464]:
```
evaluations50000_sim_mirror_d_20_real =␣
 ↪real_positions(evaluations50000_sim_mirror_d_20[24000:])
evaluations50000_sim_mirror_d_20_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_sim_mirror_d_20_real,0,20, ', original dataset, real␣
 ↪positions, SF15')
```


On plausible positions, we an see that beside for the tightest thresholds, the number of problems detected by the MRs are way lower, and increasing the depth is now improving our results. We can explain the increase in detected problems for tight thresholds with the fact that on real positions, centipawns values tend to be really lower than before. If for instance, we have a position with an evaluation with a centipawns value of 5 (meaning an advantage of 0.05 for White), and its mirrored version gets an evaluation with a centipawns value of -7 (meaning an advantage of 0.07 for Black), the delta value will be abs((5-7)/(5+7)) = 0.17, which is superior to 0.05. Since the centipawns difference is not equal to 0, the MRs will detect a problem, even though the difference is meaningless.

### 0.8.2 sim_axis

**depth = 10, entire dataset (Link V16)** Our grid in the first time.

[478]:
```
path = os.path.join('sim_axis_d=10','evaluations50000_sim_axis_d_10.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_axis_d_10 = pickle.load(file)

tests(evaluations50000_sim_axis_d_10,1,10, ', original dataset, SF15')
```


[752]:
```
from IPython.display import display, Image

display(Image(filename='originalaxis10.png',width=900,height=900))
```

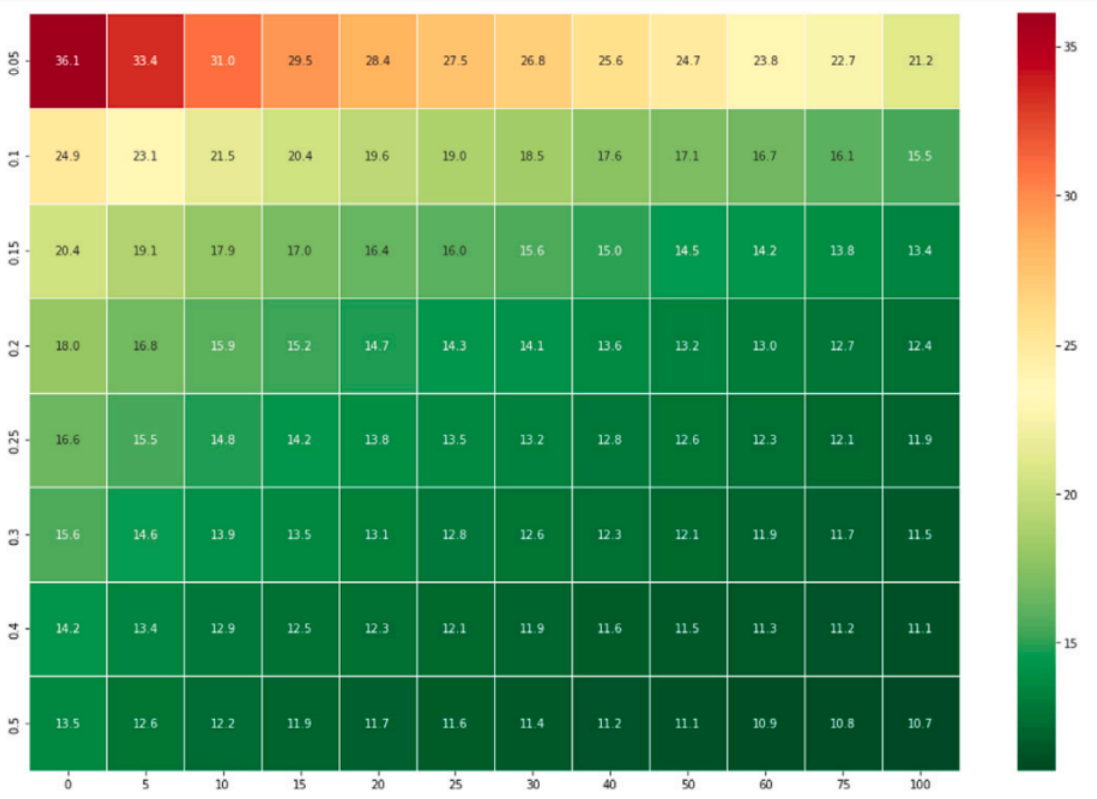



**Fig. 6.** Percentage of problems detected by $\mathrm{MR}_{\mathtt{equi}}$ using the $\mathtt{sim\_axis}(p)$ transformation. $x$-axis represents $\epsilon$ value and $y$-axis represents $\delta$ value.

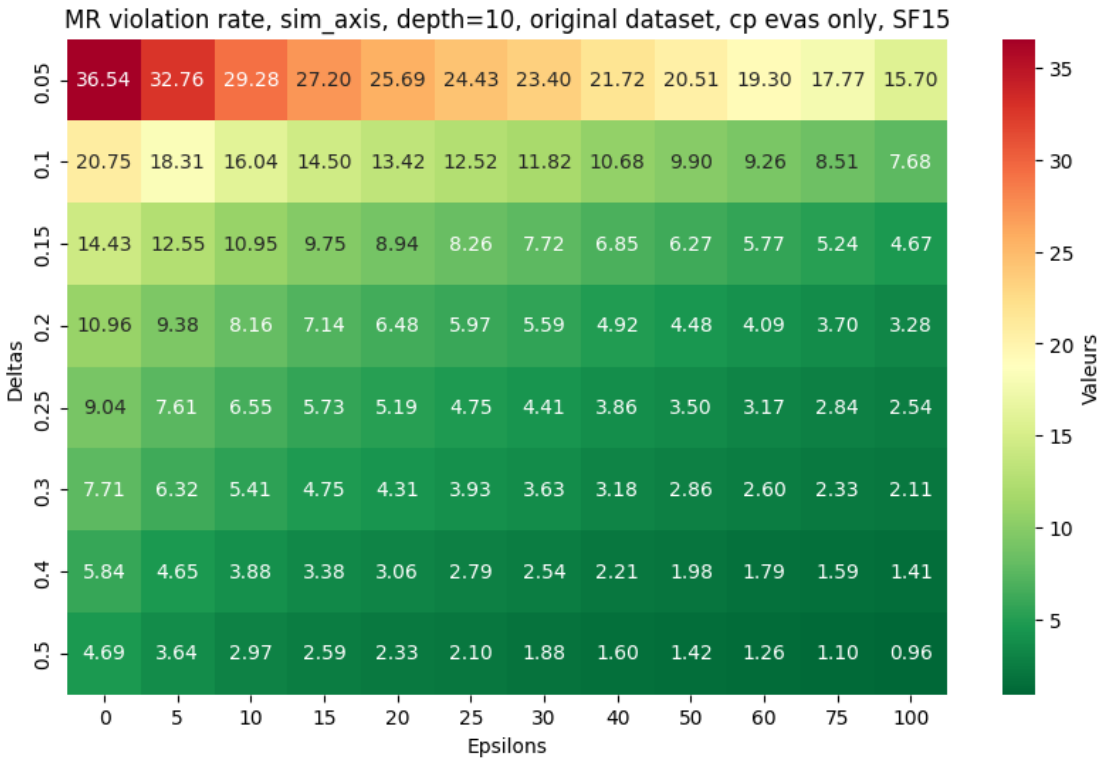
**depth = 10, splitting (Link V16)**

[38]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_sim_axis_d_10)[1])/
 ↪(len(split_mate_cp(evaluations50000_sim_axis_d_10)[0])+len(split_mate_cp(evaluations50000_s
```

```
Mates proportion :  0.28385690373311534
```

**Evaluations with a difference in centipawns**

[477]:
```
tests(split_mate_cp(evaluations50000_sim_axis_d_10)[0],1,10, ', original␣
 ↪dataset, cp evas only, SF15')
```



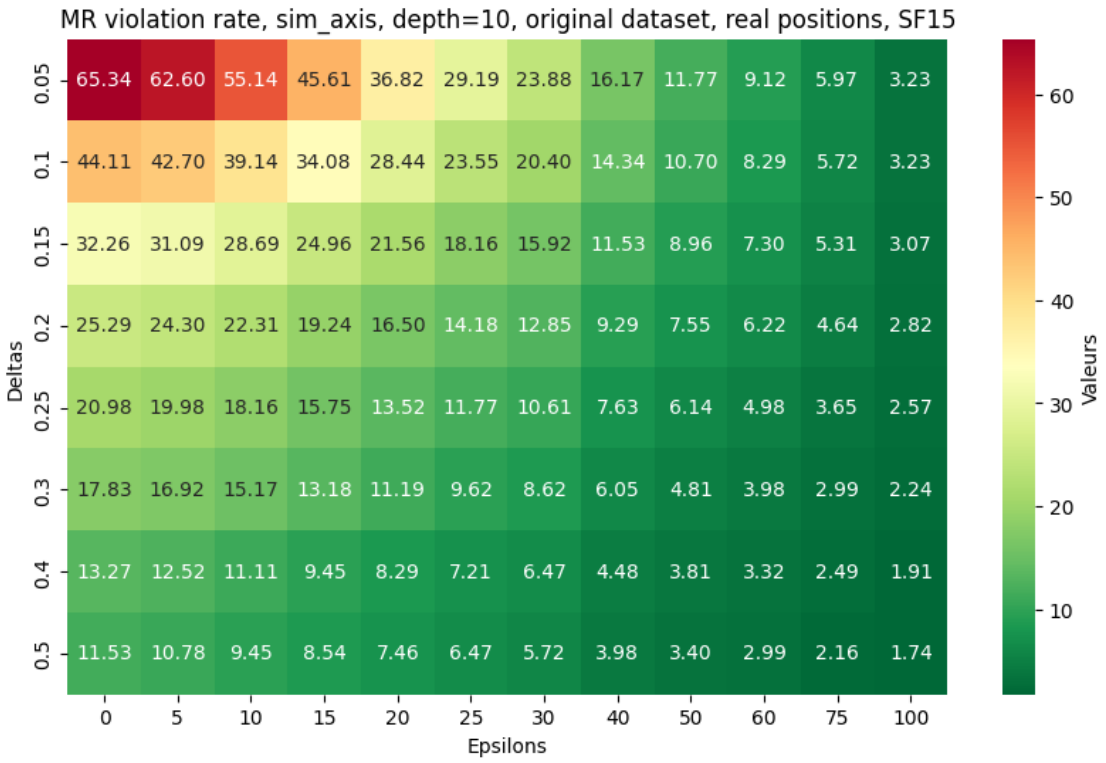

### Evaluations with a mate

[40]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_sim_axis_d_10)[1],1,1,1),'%')
```

```
Mates failure rate :  34.28414701042239 %
```

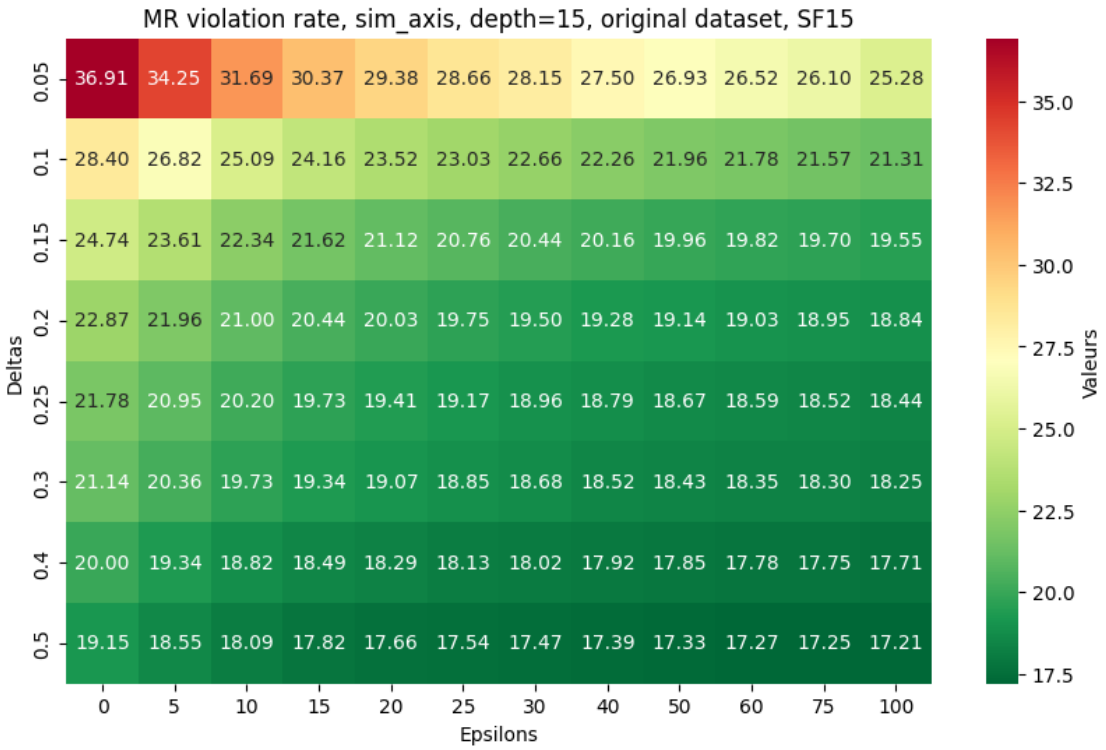
### depth = 10, real positions

[476]:
```
evaluations50000_sim_axis_d_10_real =␣
  ↪real_positions(evaluations50000_sim_axis_d_10[24000:])
evaluations50000_sim_axis_d_10_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_sim_axis_d_10_real,1,10, ', original dataset, real␣
  ↪positions, SF15')
```




**depth = 15, entire dataset**

[475]:
```
path = os.path.join('sim_axis_d=15','evaluations50000_sim_axis_d_15.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_axis_d_15 = pickle.load(file)

tests(evaluations50000_sim_axis_d_15,1,15, ', original dataset, SF15')
```



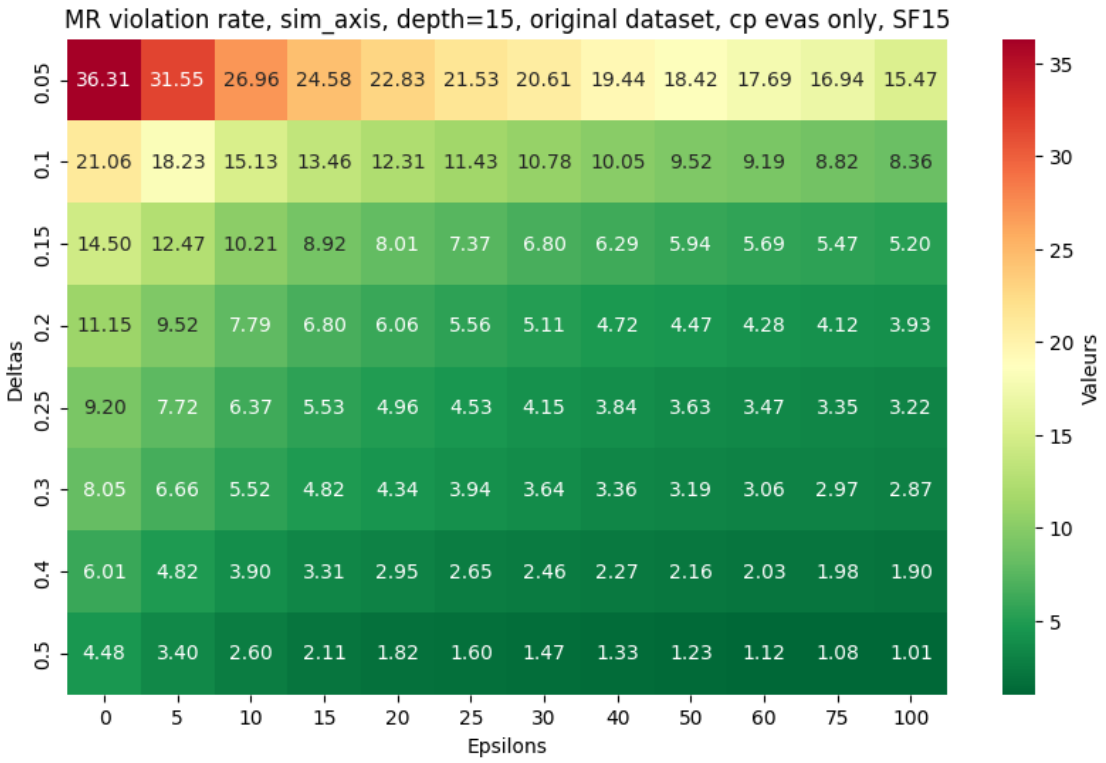

**depth = 15, splitting**

[43]:
```
print("Mates proportion : ",␣
↪len(split_mate_cp(evaluations50000_sim_axis_d_15)[1])/
↪(len(split_mate_cp(evaluations50000_sim_axis_d_15)[0])+len(split_mate_cp(evaluations50000_s
```

```
Mates proportion :  0.44193560945225213
```

**Evaluations with a difference in centipawns**

[474]:
```
tests(split_mate_cp(evaluations50000_sim_axis_d_15)[0],1,15, ', original␣
↪dataset, cp evas only, SF15')
```

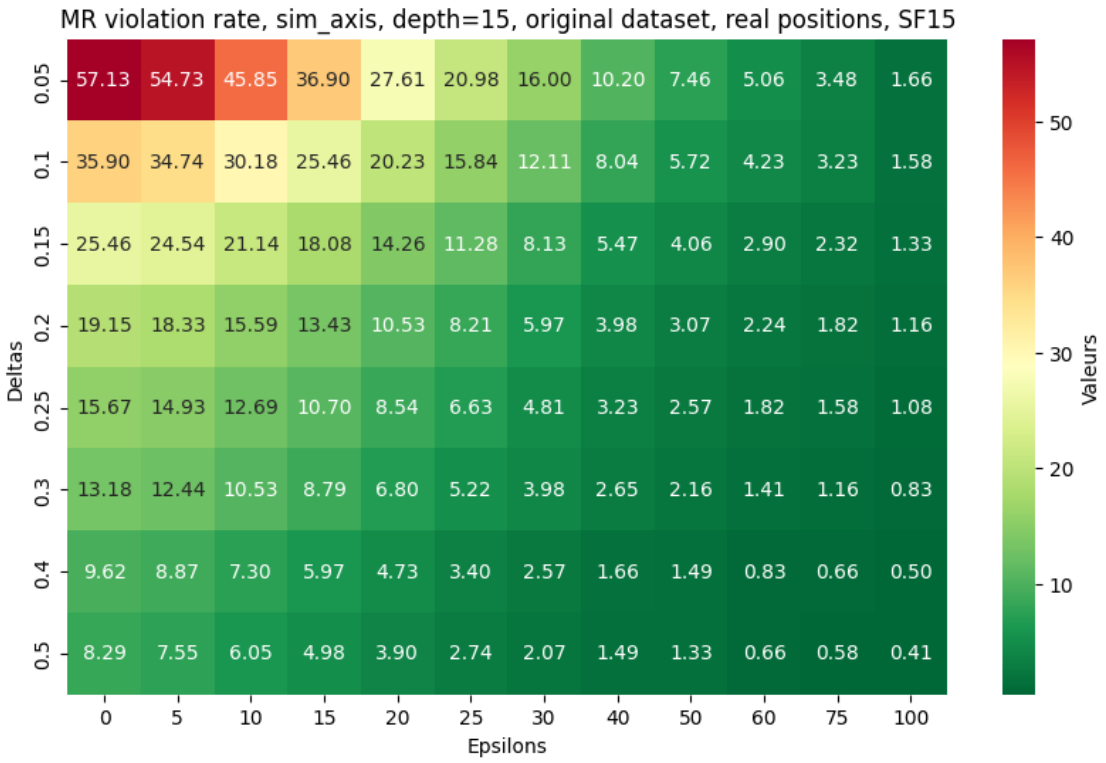



[45]:
```
print('Mates failure rate :␣
↪',100-MR(split_mate_cp(evaluations50000_sim_axis_d_15)[1],1,1,1),'%')
```

```
Mates failure rate :  37.66737138830162 %
```

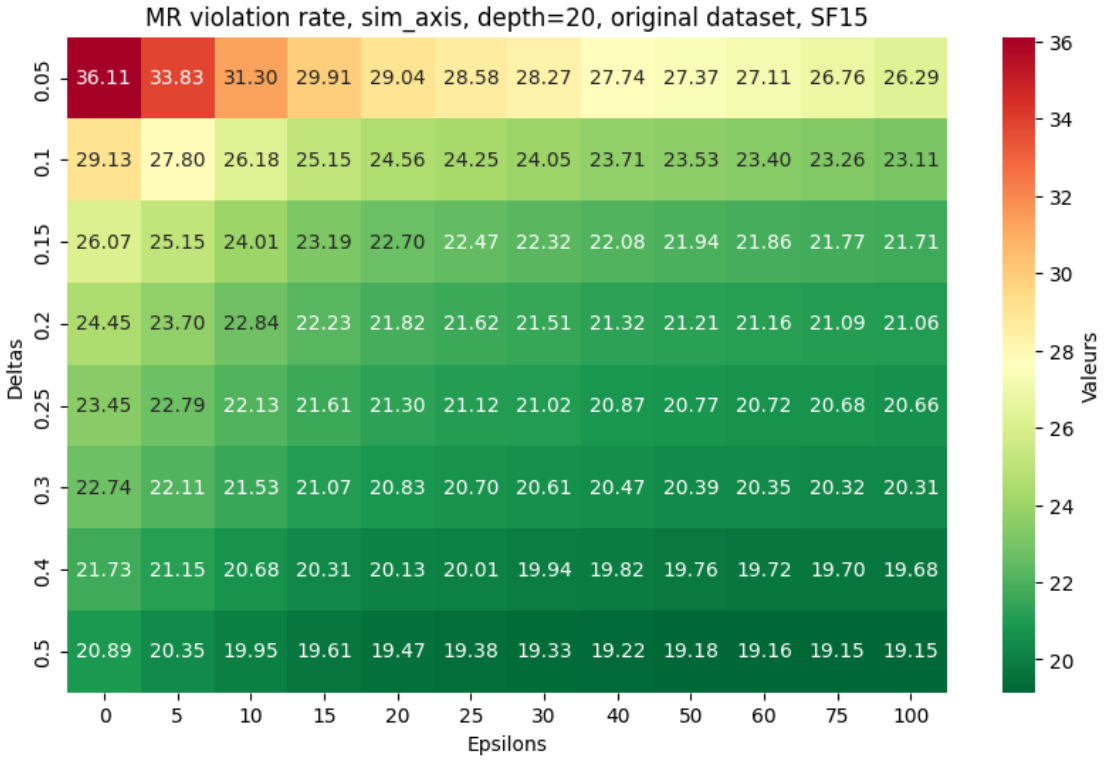
**depth = 15, real positions**

[473]:
```
evaluations50000_sim_axis_d_15_real =␣
↪real_positions(evaluations50000_sim_axis_d_15[24000:])
evaluations50000_sim_axis_d_15_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_sim_axis_d_15_real,1,15, ', original dataset, real␣
↪positions, SF15')
```




**depth = 20, entire dataset (Link V16)**

[480]:
```
path = os.path.join('sim_axis_d=20','evaluations50000_sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_axis_d_20 = pickle.load(file)

tests(evaluations50000_sim_axis_d_20,1,20, ', original dataset, SF15')
```



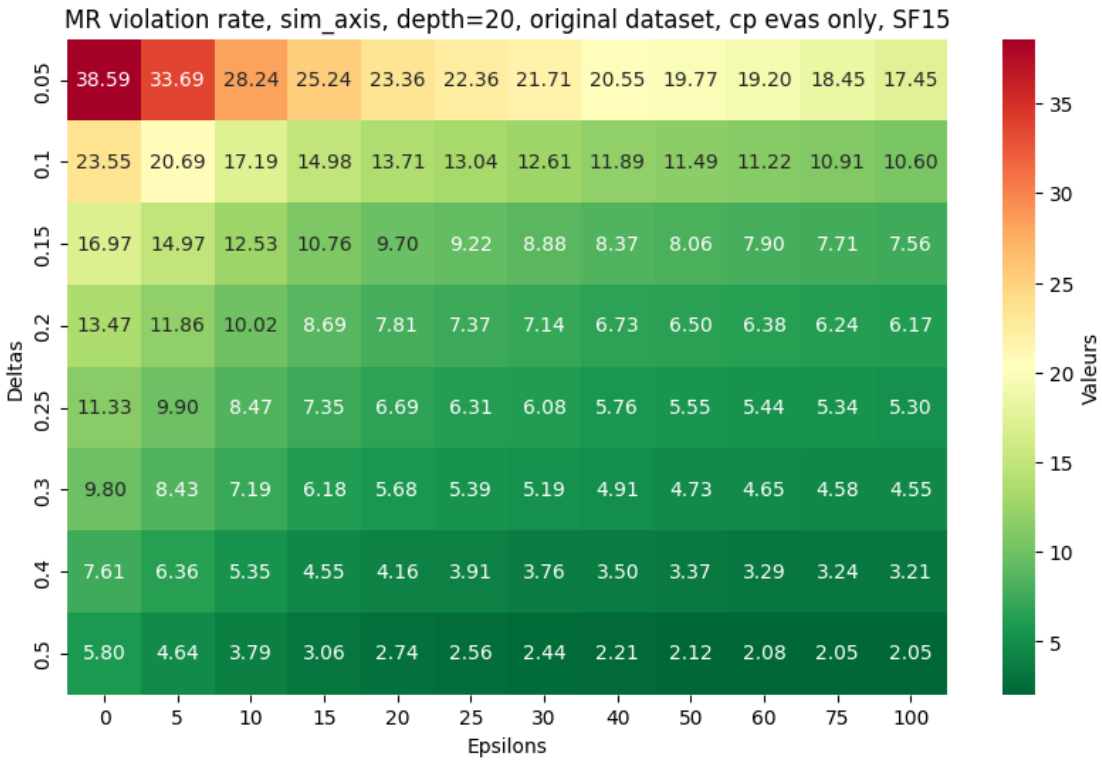

**depth = 20, splitting (Link V16)**

[48]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_sim_axis_d_20)[1])/
 ↪(len(split_mate_cp(evaluations50000_sim_axis_d_20)[0])+len(split_mate_cp(evaluations50000_s
```

```
Mates proportion :  0.5357728017476788
```

**Evaluations with a difference in centipawns**

[481]:
```
tests(split_mate_cp(evaluations50000_sim_axis_d_20)[0],1,20, ', original␣
 ↪dataset, cp evas only, SF15')
```

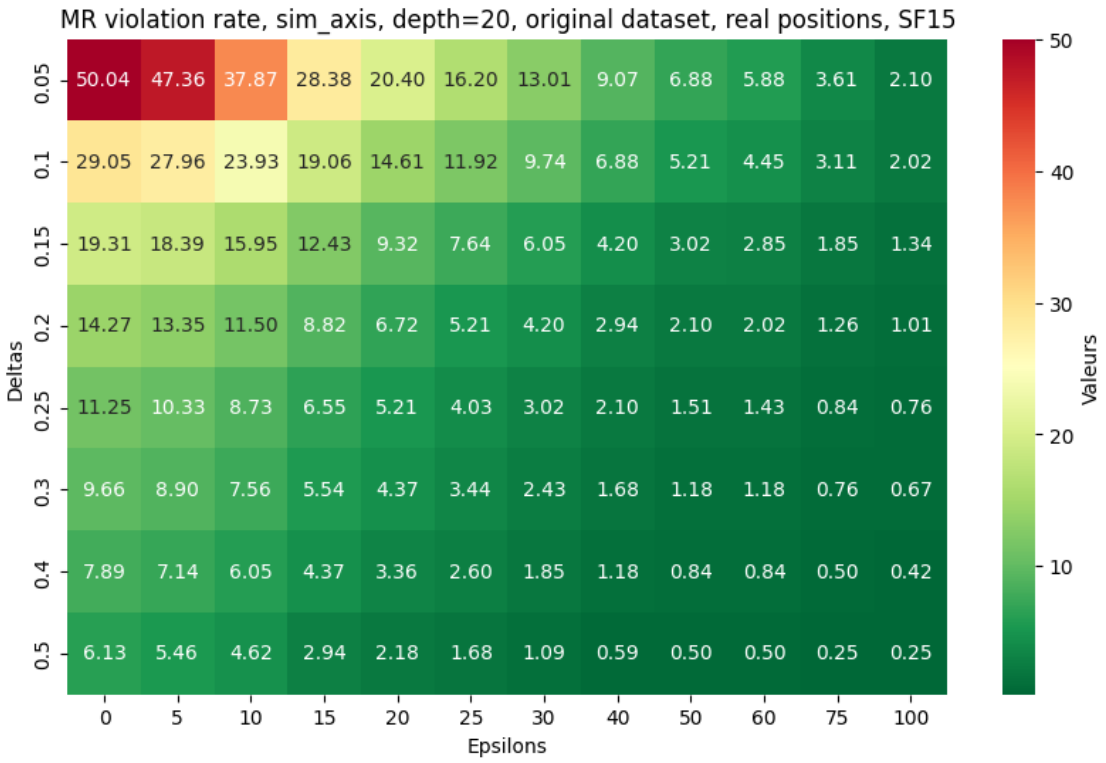



[50]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_sim_axis_d_20)[1],1,1,1),'%')
```

```
Mates failure rate :  33.95951652832386 %
```

### depth = 20, real positions (Link V16)

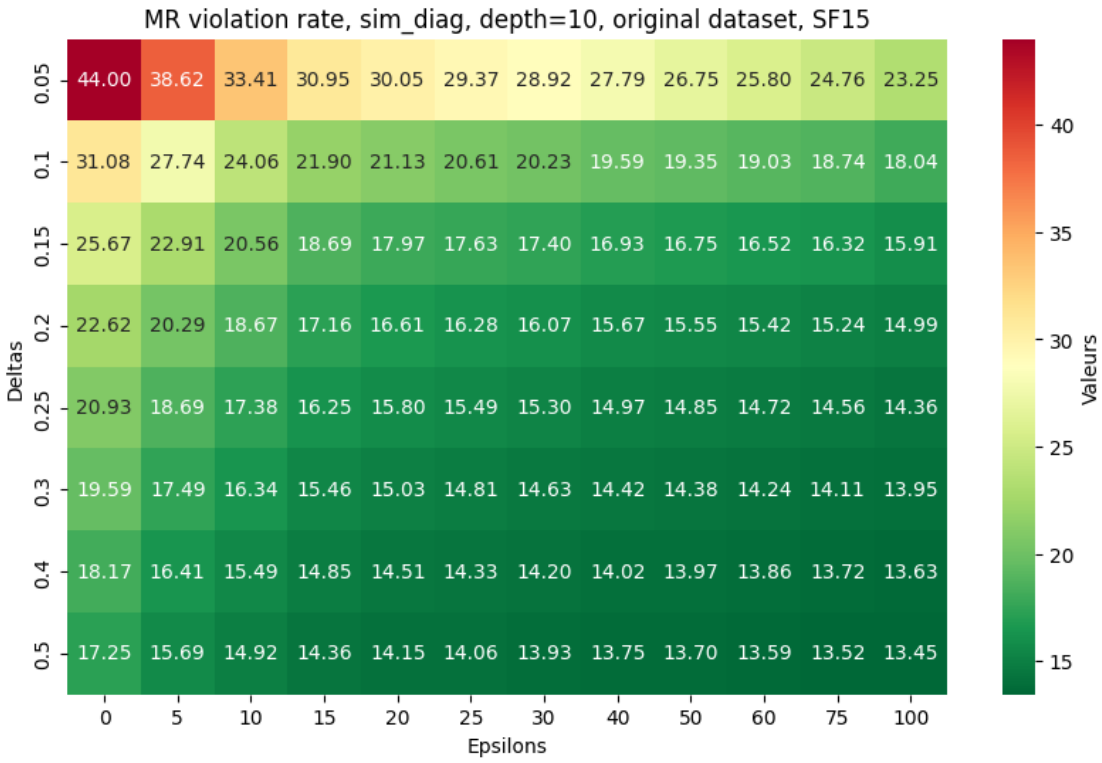
[479]:
```
evaluations50000_sim_axis_d_20_real =␣
  ↪real_positions(evaluations50000_sim_axis_d_20[24000:])
evaluations50000_sim_axis_d_20_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_sim_axis_d_20_real,1,20, ', original dataset, real␣
  ↪positions, SF15')
```




### 0.8.3 sim_diag

**depth = 10, entire dataset** Our grid.

[482]:
```
path = os.path.join('sim_diag_d=10','evaluations50000_sim_diag_d_10.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_diag_d_10 = pickle.load(file)

tests(evaluations50000_sim_diag_d_10,2,10, ', original dataset, SF15')
```




The grid from the article.

[753]:
```
from IPython.display import display, Image

display(Image(filename='originaldiag10.png',width=900,height=900))
```

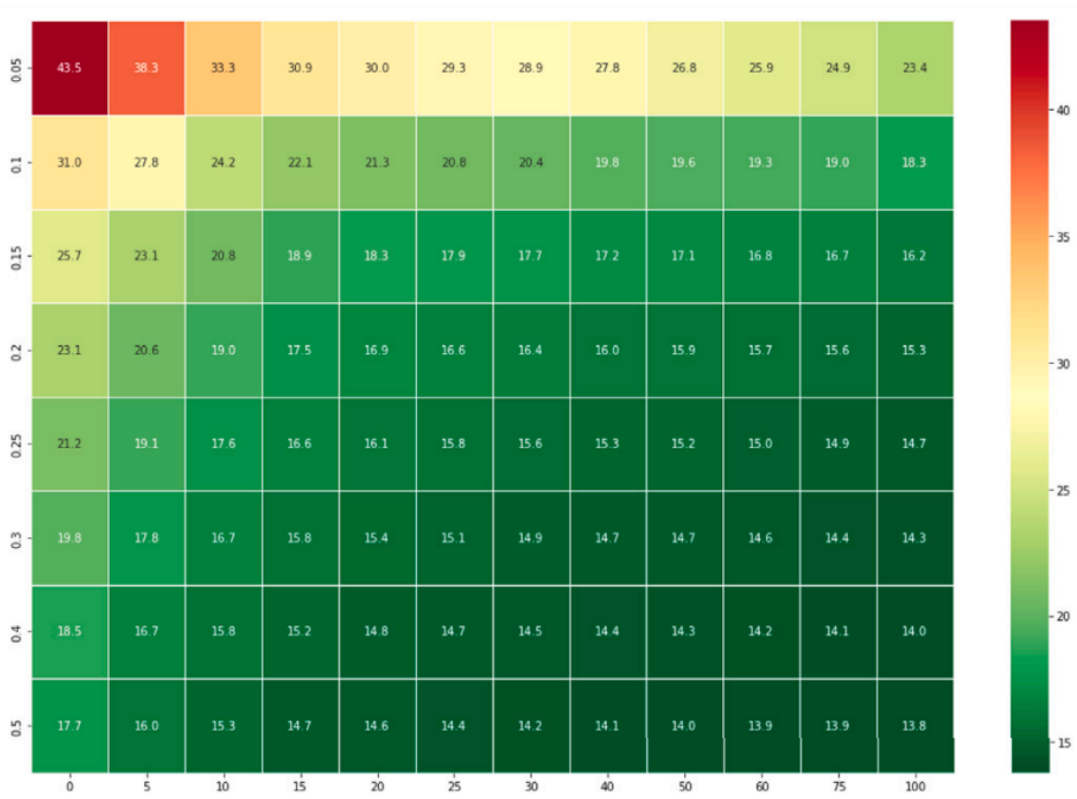



**Fig. 7.** Percentage of problems detected by $\mathtt{MR}_{\mathtt{equi}}$ using the `sim_diag`($p$) transformation. $x$-axis represents $\epsilon$ value and $y$-axis represents $\delta$ value.

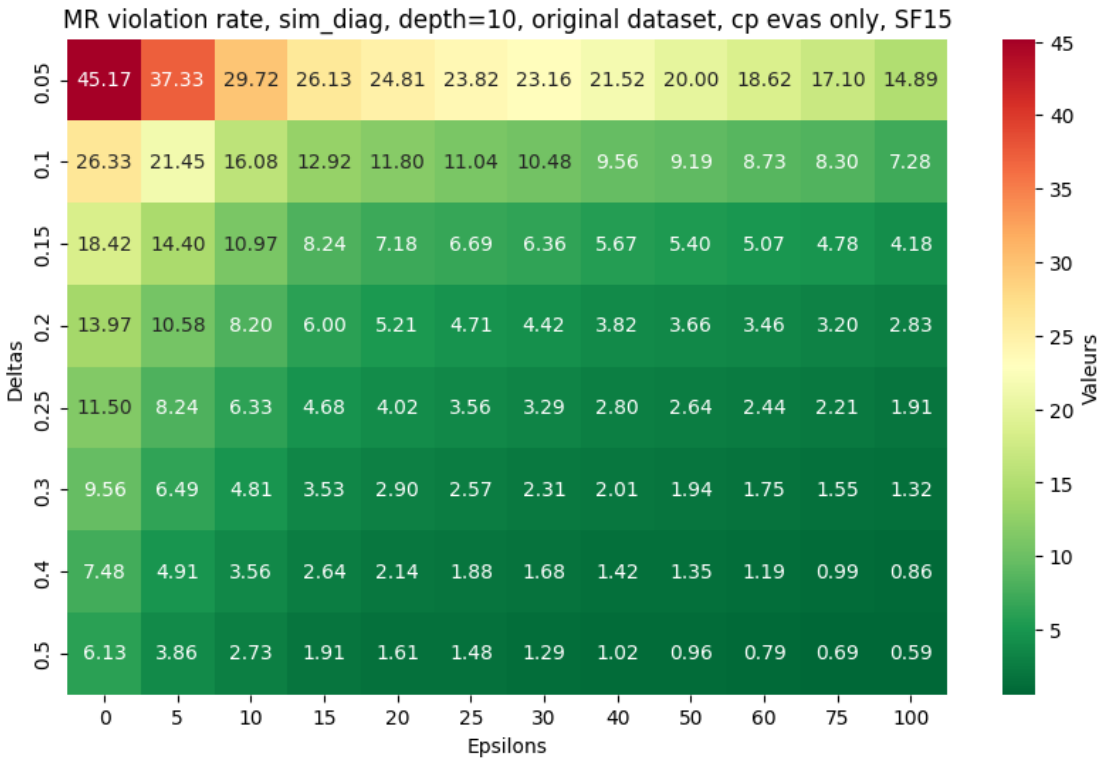
**depth = 10, splitting**

[53]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_sim_diag_d_10)[1])/
 ↪(len(split_mate_cp(evaluations50000_sim_diag_d_10)[0])+len(split_mate_cp(evaluations50000_s
```

```
Mates proportion :  0.3148984198645598
```

**Evaluations with a difference in centipawns**

[483]:
```
tests(split_mate_cp(evaluations50000_sim_diag_d_10)[0],2,10, ', original␣
 ↪dataset, cp evas only, SF15')
```




[55]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_sim_diag_d_10)[1],2,1,1),'%')
```

```
Mates failure rate :  41.43369175627241 %
```

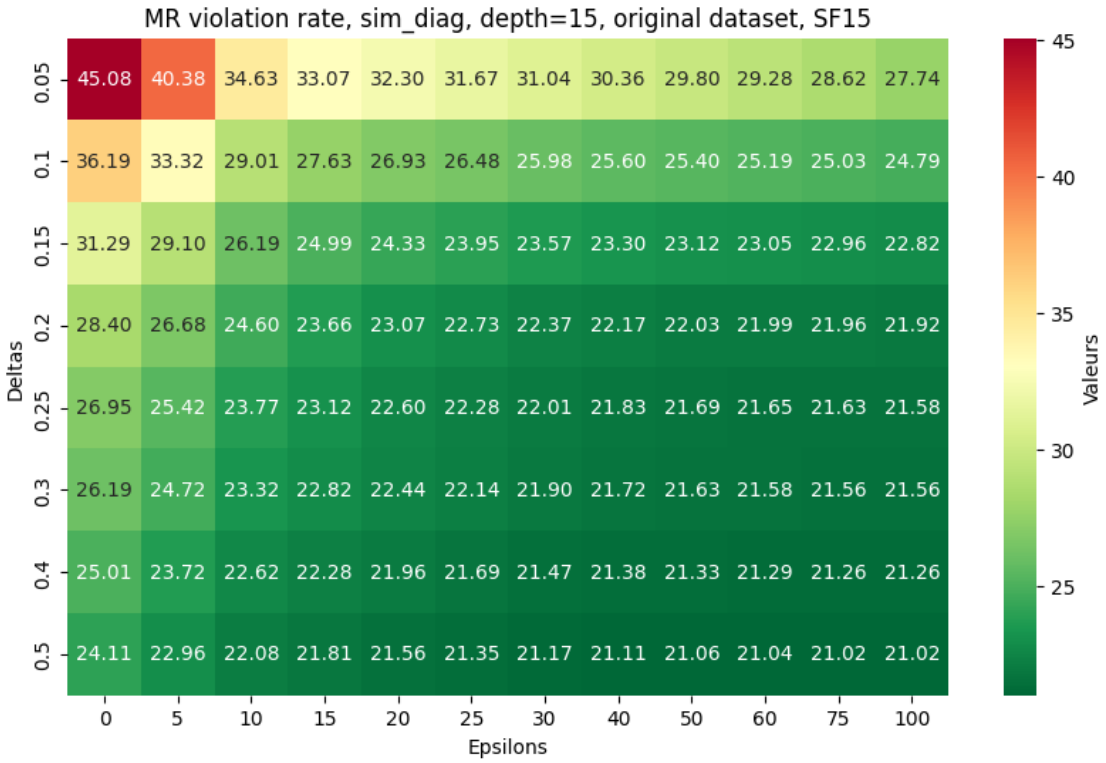
**depth = 10, real positions** Since this mutation only works on positions without any pawn, its interest on real positions is deeply lowered. Furthermore, our dataset doesn't contain real positions with no pawn.

[56]:
```
len(real_positions(evaluations50000_sim_diag_d_10))
```

[56]: 0

**depth = 15, entire dataset**

[484]:
```
path = os.path.join('sim_diag_d=15','evaluations50000_sim_diag_d_15.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_diag_d_15 = pickle.load(file)

tests(evaluations50000_sim_diag_d_15,2,15, ', original dataset, SF15')
```



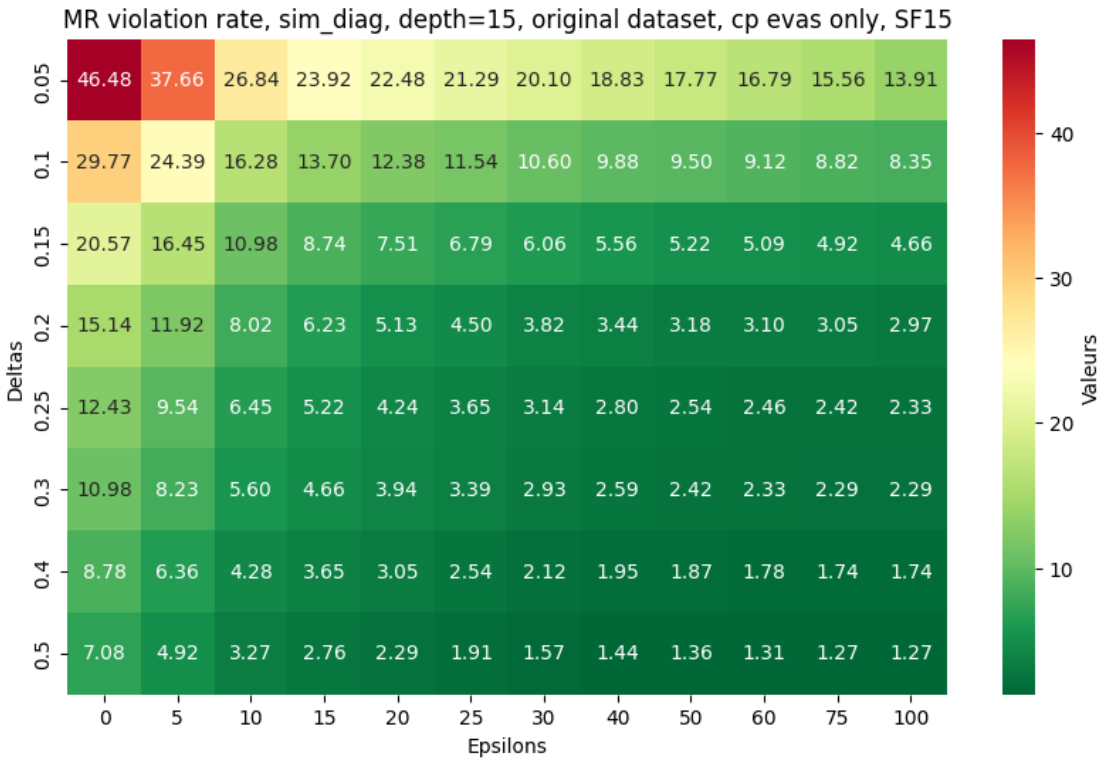

### depth = 15, splitting

[58]:
```
print("Mates proportion : ",␣
  ↪len(split_mate_cp(evaluations50000_sim_diag_d_15)[1])/
  ↪(len(split_mate_cp(evaluations50000_sim_diag_d_15)[0])+len(split_mate_cp(evaluations50000_s
```

```
Mates proportion :  0.46772009029345374
```

### Evaluations with a difference in centipawns

[485]:
```
tests(split_mate_cp(evaluations50000_sim_diag_d_15)[0],2,15, ', original␣
  ↪dataset, cp evas only, SF15')
```

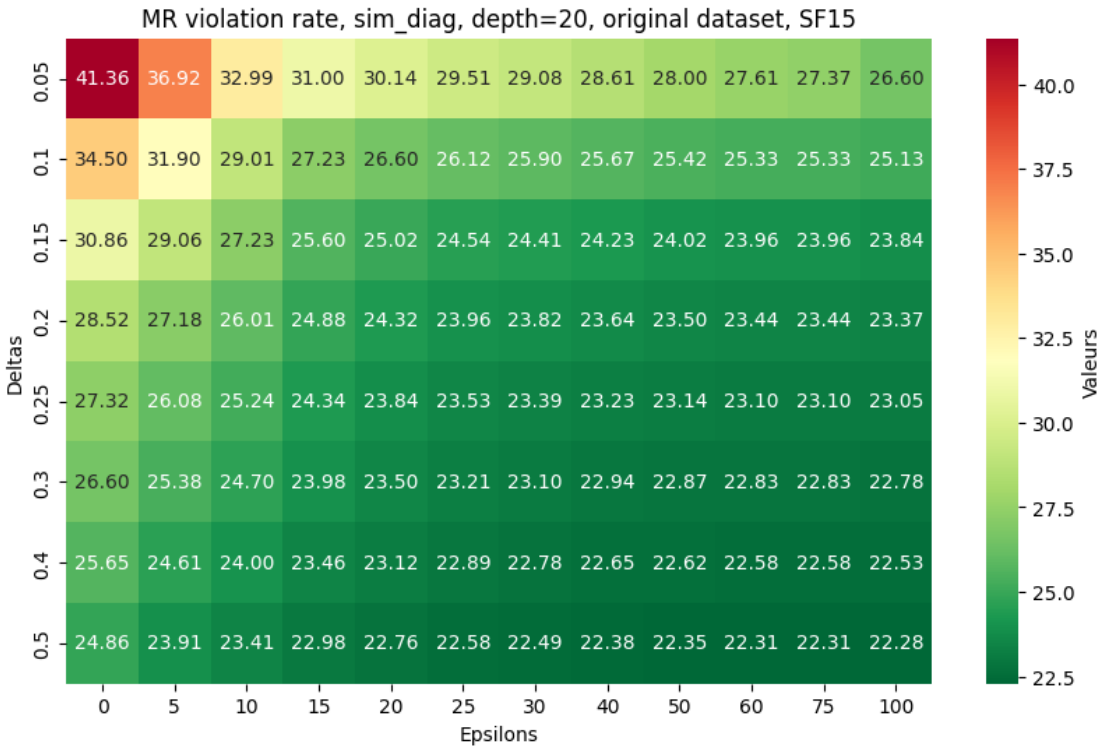



[60]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_sim_diag_d_15)[1],2,1,1),'%')
```

```
Mates failure rate :  43.48455598455598 %
```

**depth = 20, entire dataset (Link V16)**

[486]:
```
path = os.path.join('sim_diag_d=20','evaluations50000_sim_diag_d_20.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_diag_d_20 = pickle.load(file)

tests(evaluations50000_sim_diag_d_20,2,20, ', original dataset, SF15')
```



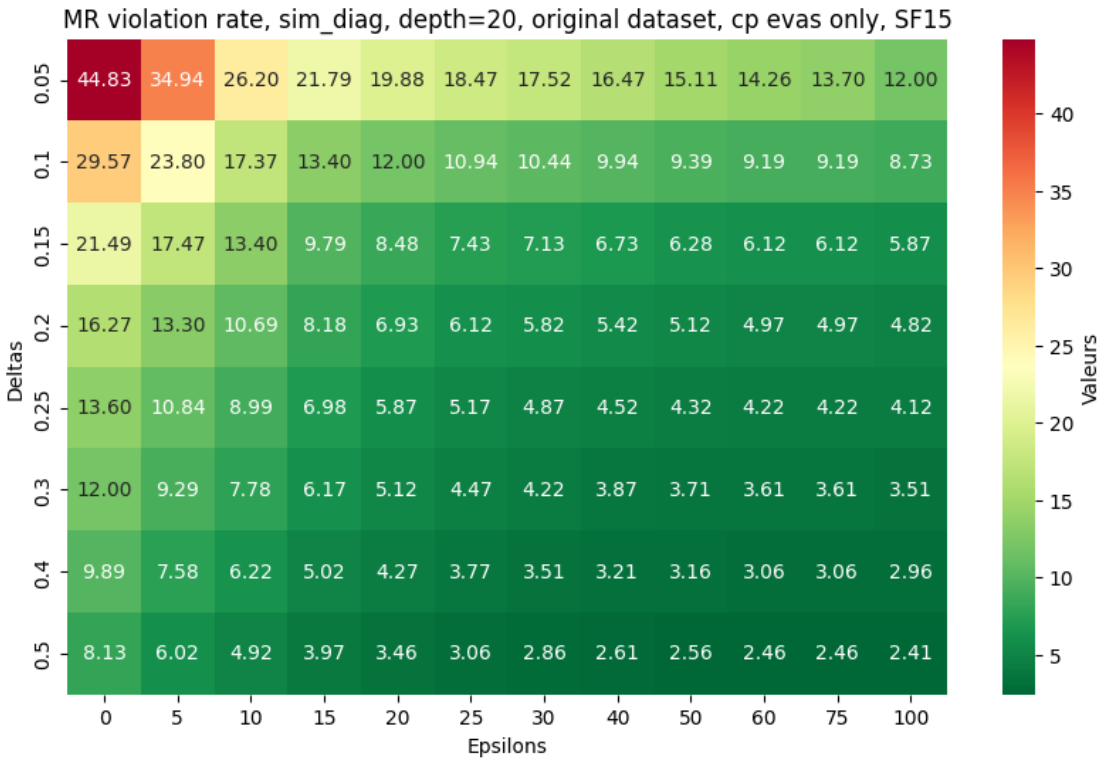

**depth = 20, splitting (Link V16)**

[62]:
```
print("Mates proportion : ",␣
↪len(split_mate_cp(evaluations50000_sim_diag_d_20)[1])/
↪(len(split_mate_cp(evaluations50000_sim_diag_d_20)[0])+len(split_mate_cp(evaluations50000_s
```

```
Mates proportion :  0.5502370738315647
```

**Evaluations with a difference in centipawns**

[487]:
```
tests(split_mate_cp(evaluations50000_sim_diag_d_20)[0],2,20, ', original␣
↪dataset, cp evas only, SF15')
```




[64]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_sim_diag_d_20)[1],2,1,1),'%')
```

```
Mates failure rate :  38.53098071399261 %
```

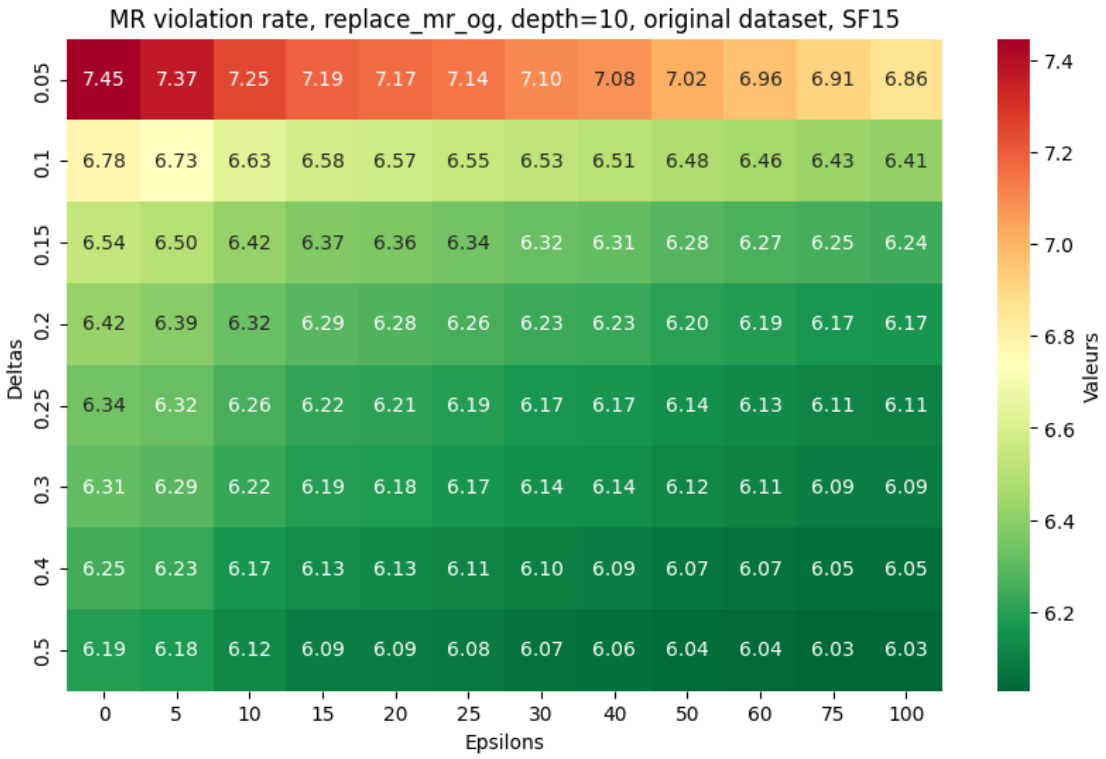
### 0.8.4 replace

**depth = 10, entire dataset** Our grid (note, the MR was slightly edited).

[488]:
```
path = os.path.join('replace_d=10','evaluations50000_replace_d_10.pkl')
with open(path, 'rb') as file:
    evaluations50000_replace_d_10 = pickle.load(file)

tests(evaluations50000_replace_d_10,3,10, ', original dataset, SF15')
```


Using the original MR_better, not edited:

[757]:
```
tests(evaluations50000_replace_d_10,6,10, ', original dataset, SF15')
```




The grid from the article.

[754]:
```
from IPython.display import display, Image

display(Image(filename='originalreplace10.png',width=900,height=900))
```

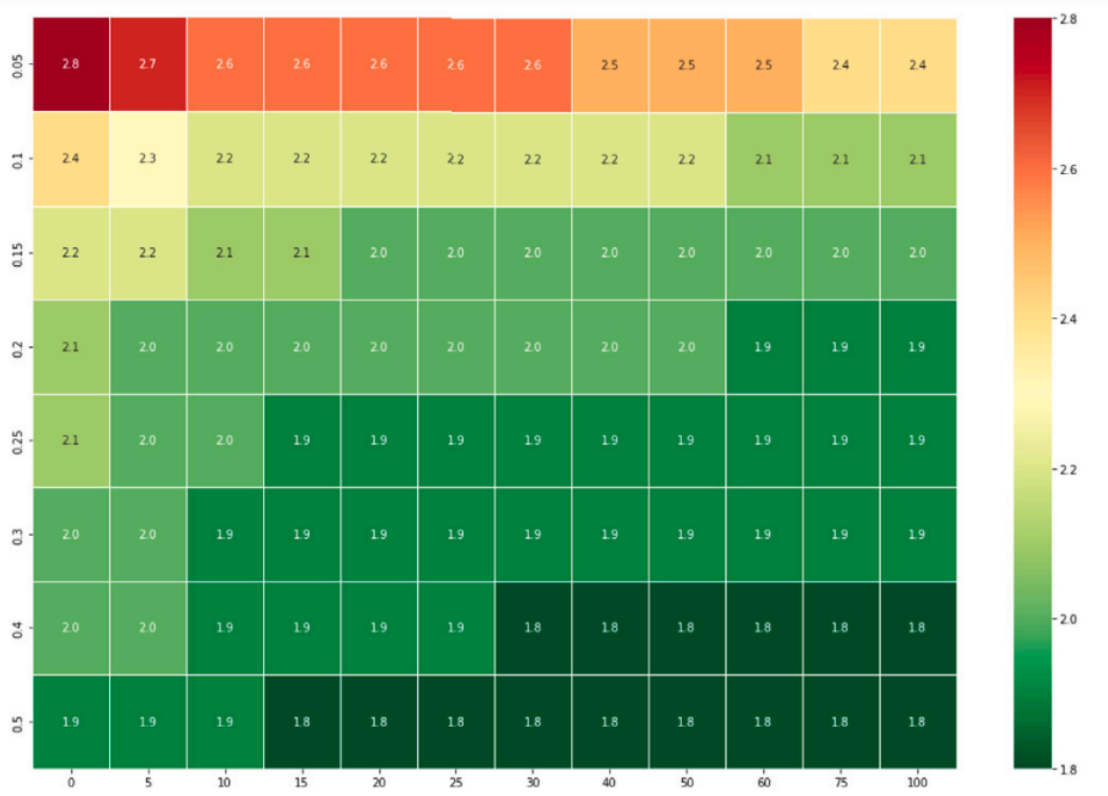



**Fig. 9.** Percentage of problems detected by $\mathrm{MR}_{\mathrm{better}}$. $x$-axis represents $\epsilon$ value and $y$-axis represents $\delta$ value.

The grid from the article is closer to the grid with the corrected MR_better than the one with the MR_better that was in their GitHub. Two hypothesis: they actually used a correct MR_better and put somehow another one on GitHub, or they did not filter the positions which had no white bishops nor white rooks.

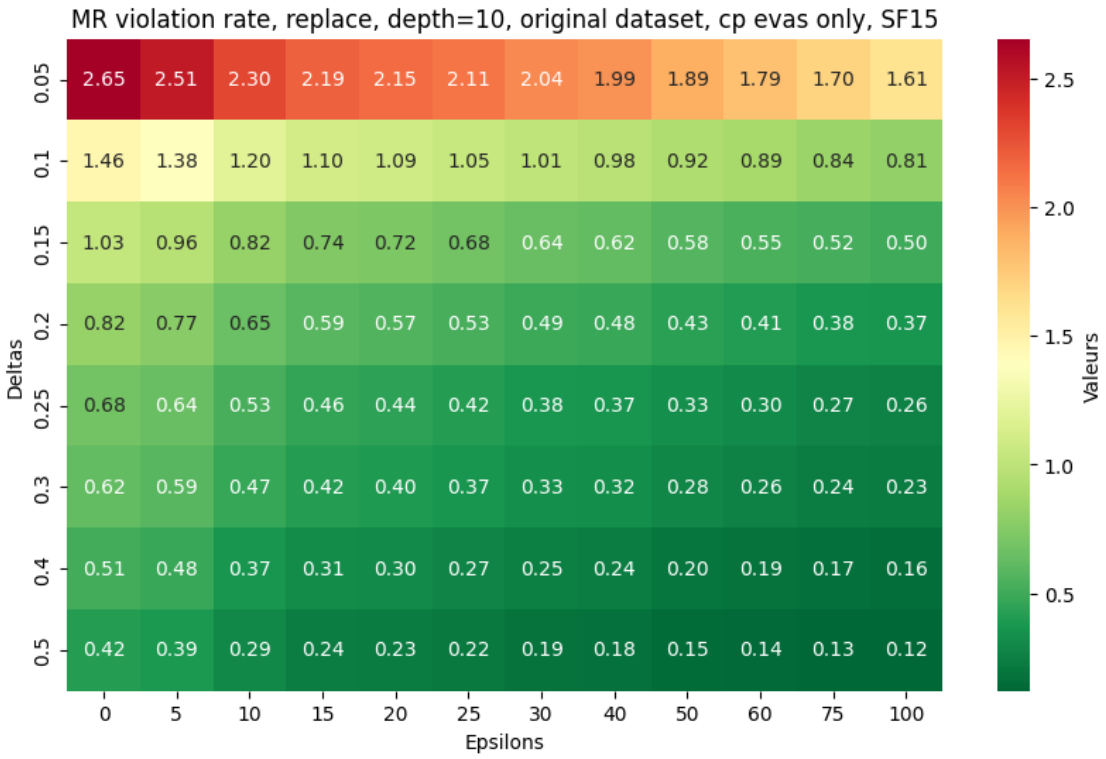
**depth = 10, splitting**

[66]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_replace_d_10)[1])/
 ↪(len(split_mate_cp(evaluations50000_replace_d_10)[0])+len(split_mate_cp(evaluations50000_re
```

```
Mates proportion :  0.43926964805504104
```

**Evaluations with a difference in centipawns**

[490]:
```
tests(split_mate_cp(evaluations50000_replace_d_10)[0],3,10, ', original␣
 ↪dataset, cp evas only, SF15')
```

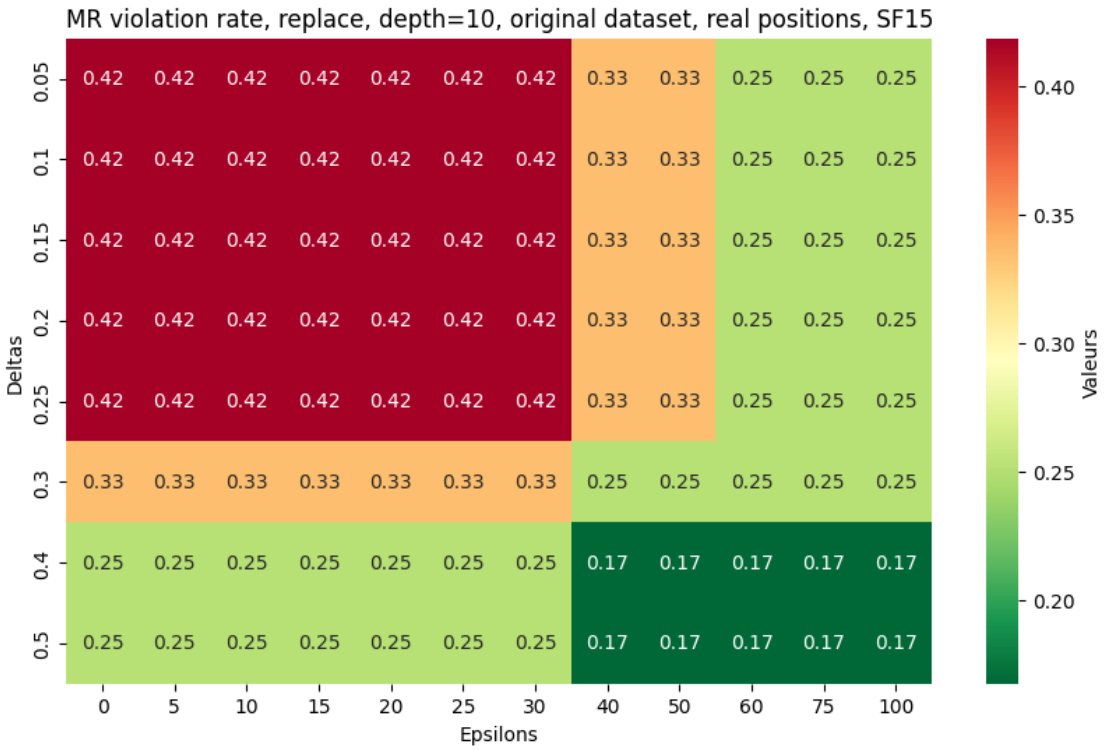



[68]:
```
print('Mates failure rate :␣
↪',100-MR(split_mate_cp(evaluations50000_replace_d_10)[1],3,1,1),'%')
```

```
Mates failure rate :  2.2530120481927725 %
```

**depth = 10, real positions**

[491]:
```
evaluations50000_replace_d_10_real =␣
↪real_positions(evaluations50000_replace_d_10[17000:])
evaluations50000_replace_d_10_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_replace_d_10_real,3,10, ', original dataset, real␣
↪positions, SF15')
```




**depth = 15, entire dataset**

[492]:
```
path = os.path.join('replace_d=15','evaluations50000_replace_d_15.pkl')
with open(path, 'rb') as file:
    evaluations50000_replace_d_15 = pickle.load(file)

tests(evaluations50000_replace_d_15,3,15, ', original dataset, SF15')
```

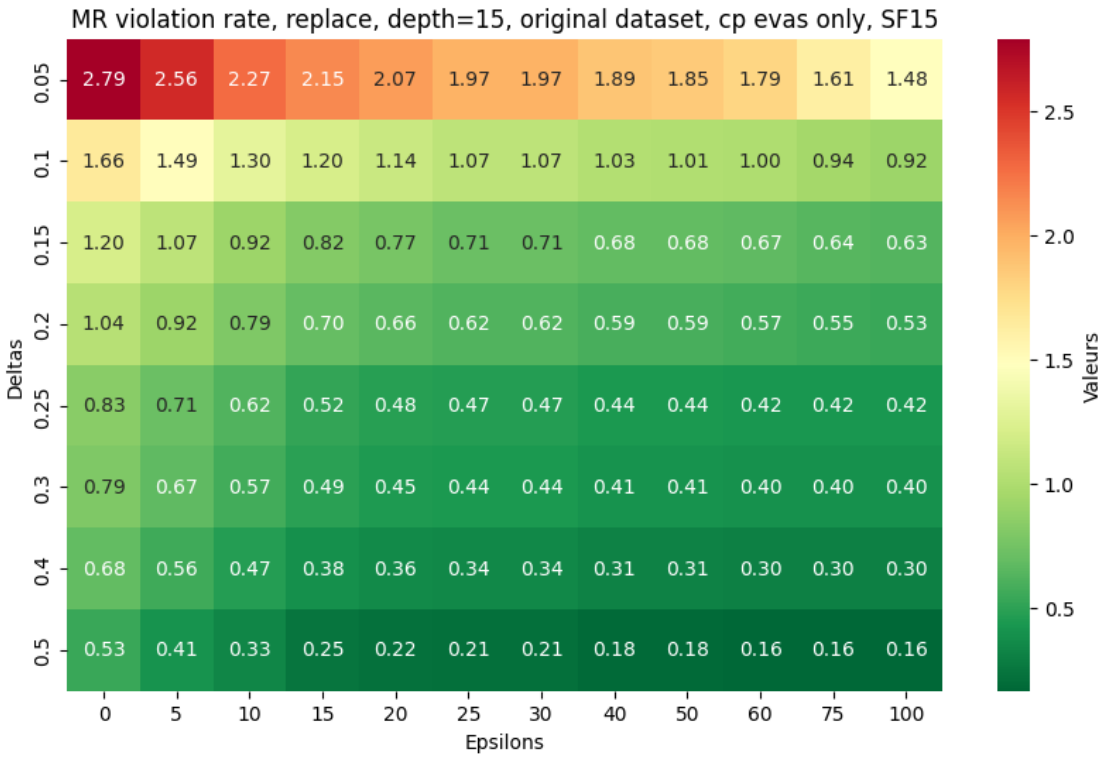

**depth = 15, splitting**

[71]:
```
print("Mates proportion : ",␣
↪len(split_mate_cp(evaluations50000_replace_d_15)[1])/
↪(len(split_mate_cp(evaluations50000_replace_d_15)[0])+len(split_mate_cp(evaluations50000_re
```

```
Mates proportion :  0.6127066553624417
```

**Evaluations with a difference in centipawns**

[494]:
```
tests(split_mate_cp(evaluations50000_replace_d_15)[0],3,15, ', original␣
↪dataset, cp evas only, SF15')
```




[73]:
```
print('Mates failure rate :␣
↪',100-MR(split_mate_cp(evaluations50000_replace_d_15)[1],3,1,1),'%')
```

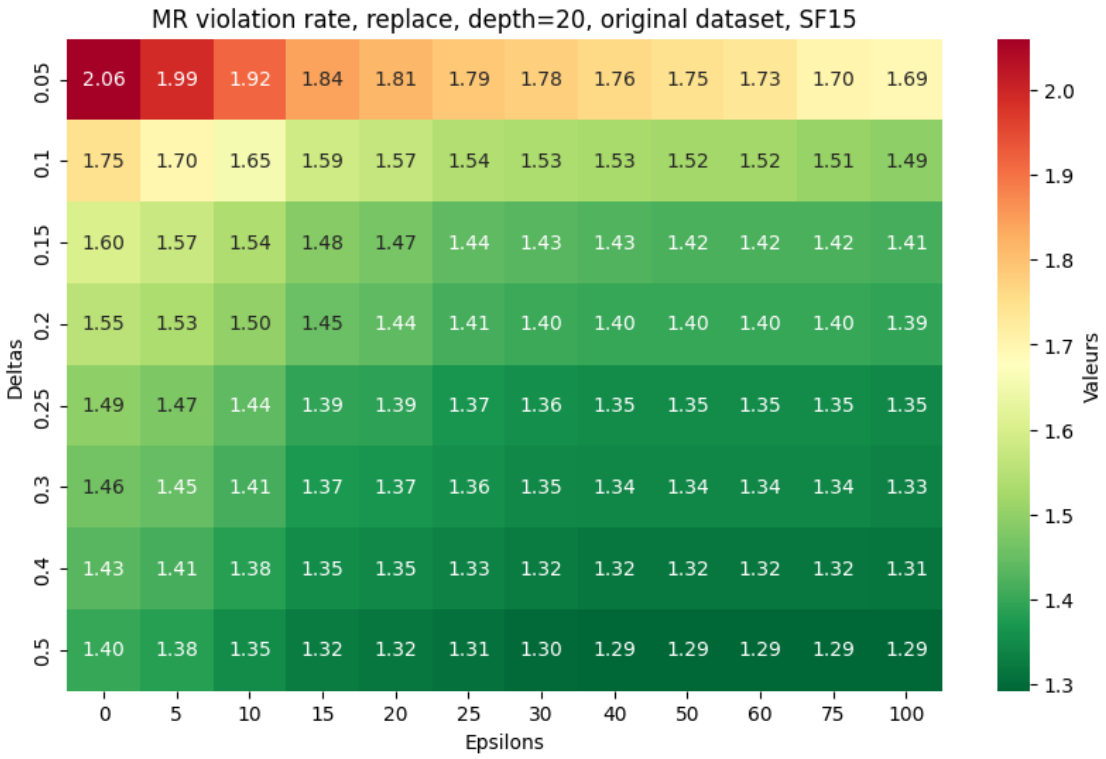
```
Mates failure rate :  2.084234195278043 %
```

### depth = 15, real positions

[493]:
```
evaluations50000_replace_d_15_real =␣
↪real_positions(evaluations50000_replace_d_15[17000:])
evaluations50000_replace_d_15_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_replace_d_15_real,3,15, ', original dataset, real␣
↪positions, SF15')
```


**depth = 20, entire dataset (Link V16)**

[495]:
```
path = os.path.join('replace_d=20','evaluations50000_replace_d_20.pkl')
with open(path, 'rb') as file:
    evaluations50000_replace_d_20 = pickle.load(file)

tests(evaluations50000_replace_d_20,3,20, ', original dataset, SF15')
```



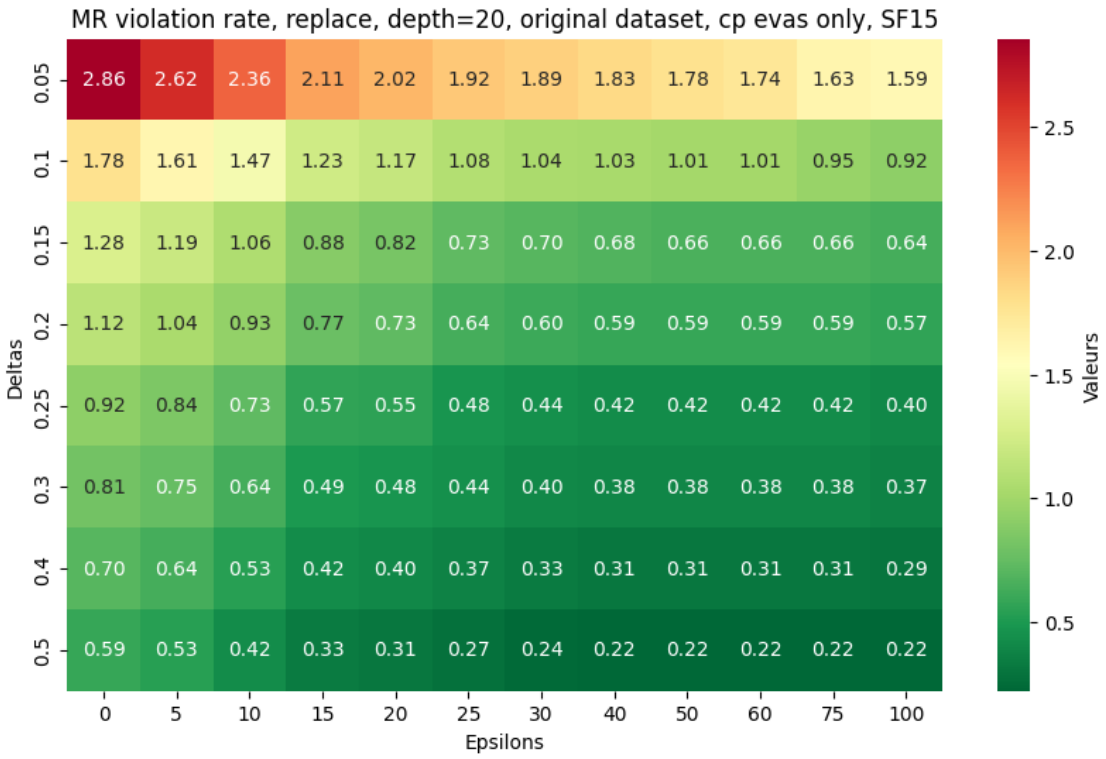

**depth = 20, splitting (Link V16)**

[76]:
```
print("Mates proportion : ",␣
↪len(split_mate_cp(evaluations50000_replace_d_20)[1])/
↪(len(split_mate_cp(evaluations50000_replace_d_20)[0])+len(split_mate_cp(evaluations50000_re
```

```
Mates proportion :  0.7085891208028613
```

**Evaluations with a difference in centipawns**

[496]:
```
tests(split_mate_cp(evaluations50000_replace_d_20)[0],3,20, ', original␣
↪dataset, cp evas only, SF15')
```




[78]:
```
print('Mates failure rate :␣
↪',100-MR(split_mate_cp(evaluations50000_replace_d_20)[1],3,1,1),'%')
```

```
Mates failure rate :  1.7327105620009036 %
```

### depth = 20, real positions (Link V16)

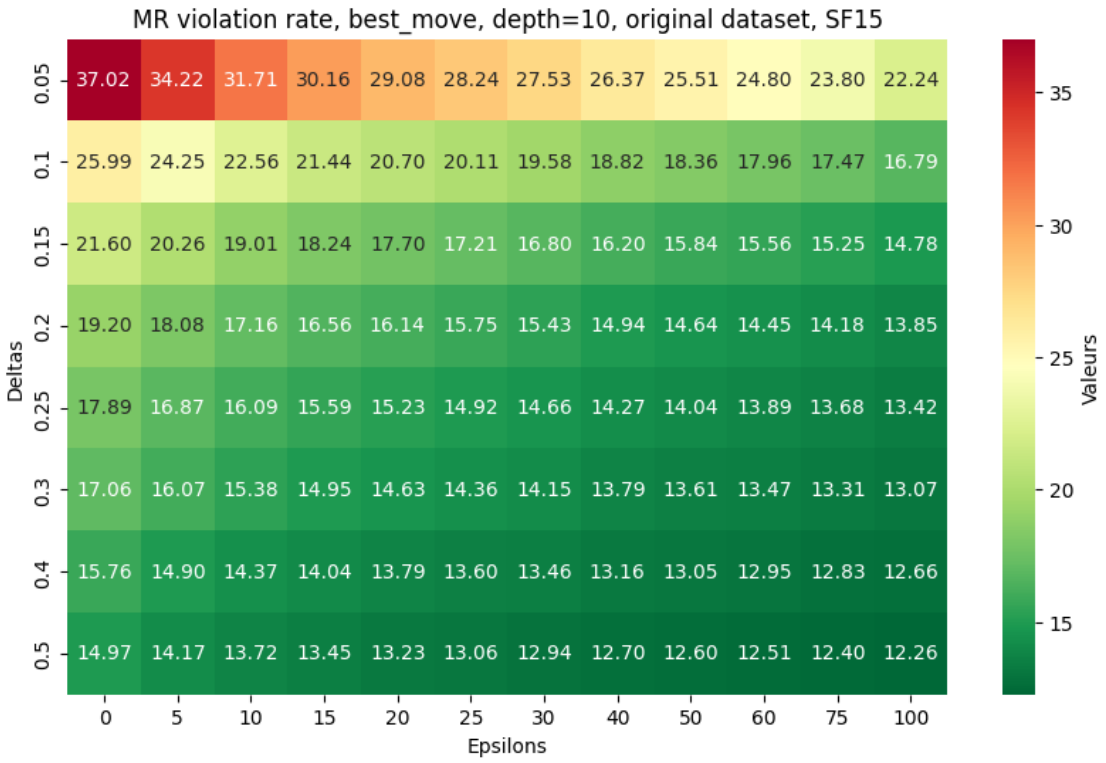
[497]:
```
evaluations50000_replace_d_20_real =␣
↪real_positions(evaluations50000_replace_d_20[17000:])
evaluations50000_replace_d_20_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_replace_d_20_real,3,20, ', original dataset, real␣
↪positions, SF15')
```


### 0.8.5 best_move

In this part, we are using sim_axis then taking the evaluation after the best move (according to Stockfish) is played.

**depth = 10, entire dataset** Our grid:

[498]:
```
path = os.path.join('best_move_d=10','evaluations50000_best_move_d_10.pkl')
with open(path, 'rb') as file:
    evaluations50000_best_move_d_10 = pickle.load(file)

tests(evaluations50000_best_move_d_10,4,10, ', original dataset, SF15')
```




The grid from their article.

[758]:
```
from IPython.display import display, Image

display(Image(filename='originalfirst10.png',width=900,height=900))
```

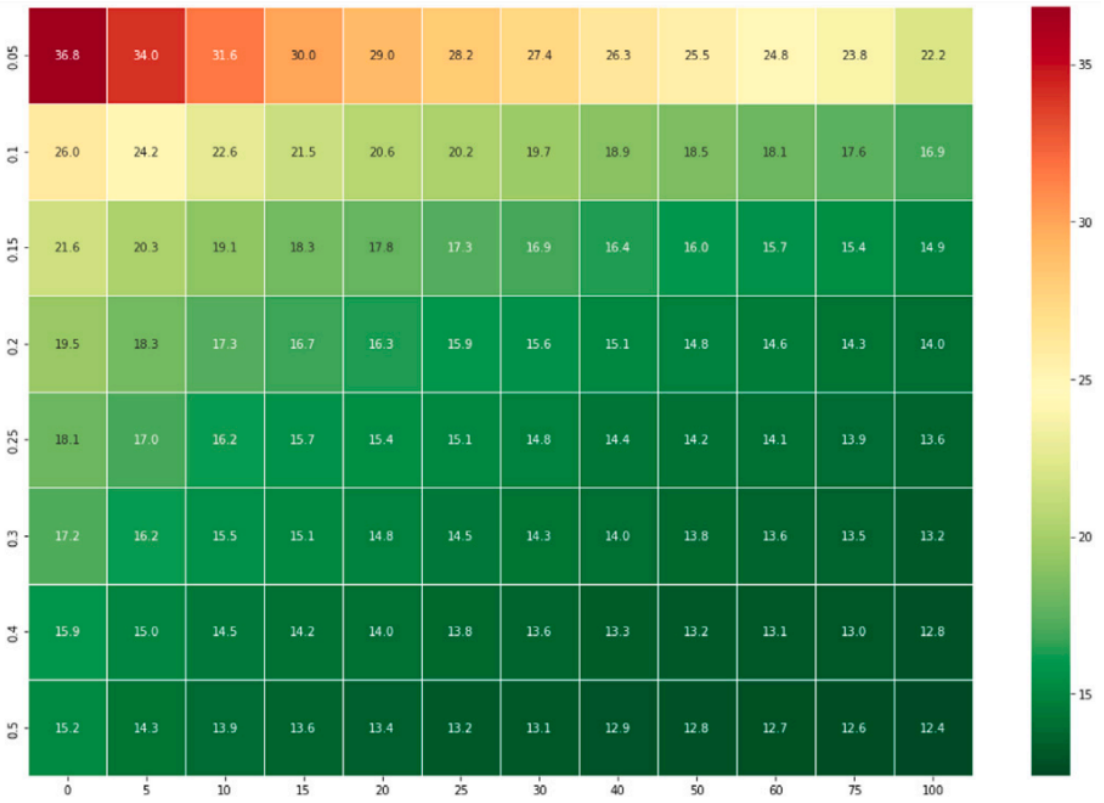


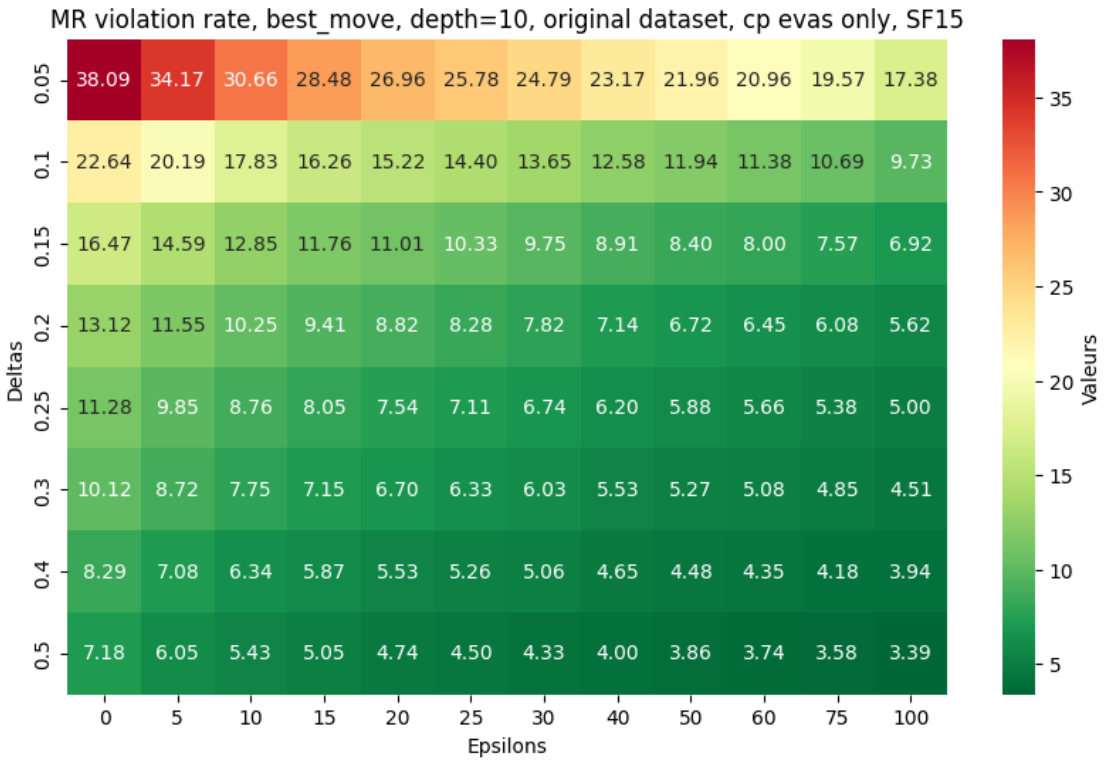

**Fig. 10.** Percentage of problems detected by $\mathrm{MR}_{\mathtt{first}}$ using the `sim_axis`($p$ transformation. $x$-axis represents $\epsilon$ value and $y$-axis represents $\delta$ value.

**depth = 10, splitting**

[81]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_best_move_d_10)[1])/
 ↪(len(split_mate_cp(evaluations50000_best_move_d_10)[0])+len(split_mate_cp(evaluations50000_
```

```
Mates proportion :  0.28685196136408436
```

[499]:
```
tests(split_mate_cp(evaluations50000_best_move_d_10)[0],4,10, ', original␣
 ↪dataset, cp evas only, SF15')
```




[83]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_best_move_d_10)[1],4,1,1),'%')
```

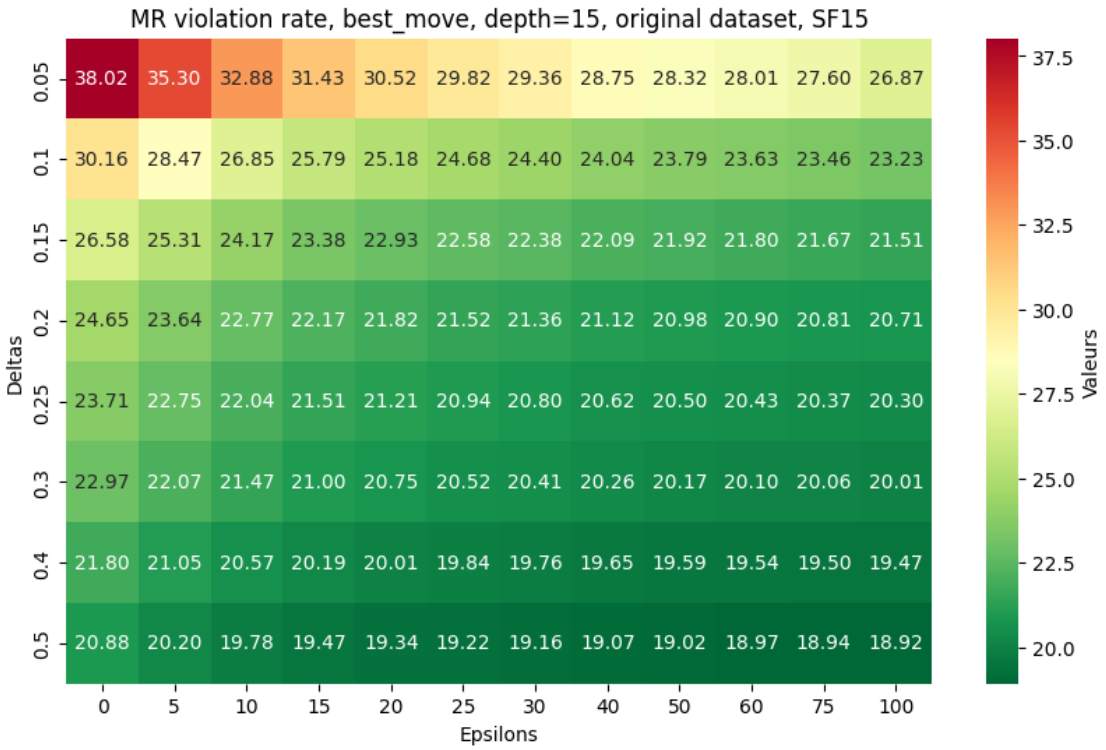
```
Mates failure rate :  34.33205057724025 %
```

**depth = 10, real positions**

[500]:
```
evaluations50000_best_move_d_10_real =␣
  ↪real_positions(evaluations50000_best_move_d_10[24000:])
evaluations50000_best_move_d_10_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_best_move_d_10_real,4,10, ', original dataset, real␣
  ↪positions, SF15')
```


**depth = 15, entire dataset**

[501]:
```
path = os.path.join('best_move_d=15','evaluations50000_best_move_d_15.pkl')
with open(path, 'rb') as file:
    evaluations50000_best_move_d_15 = pickle.load(file)

tests(evaluations50000_best_move_d_15,4,15, ', original dataset, SF15')
```




**depth = 15, splitting**

[86]:
```
print("Mates proportion : ",␣
↪len(split_mate_cp(evaluations50000_best_move_d_15)[1])/
↪(len(split_mate_cp(evaluations50000_best_move_d_15)[0])+len(split_mate_cp(evaluations50000_
```

```
Mates proportion :  0.43591057840160863
```

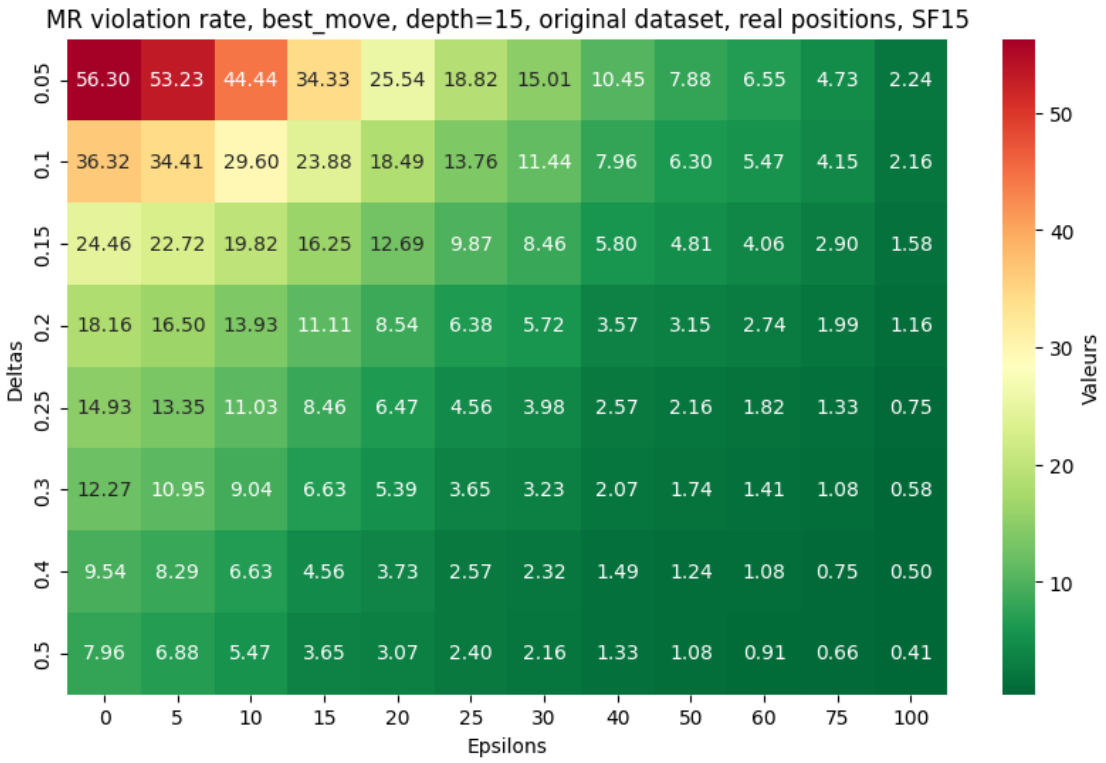
[502]:
```
tests(split_mate_cp(evaluations50000_best_move_d_15)[0],4,15, ', original␣
↪dataset, cp evas only, SF15')
```


[88]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_best_move_d_15)[1],4,1,1),'%')
```

```
Mates failure rate :  37.30101302460203 %
```

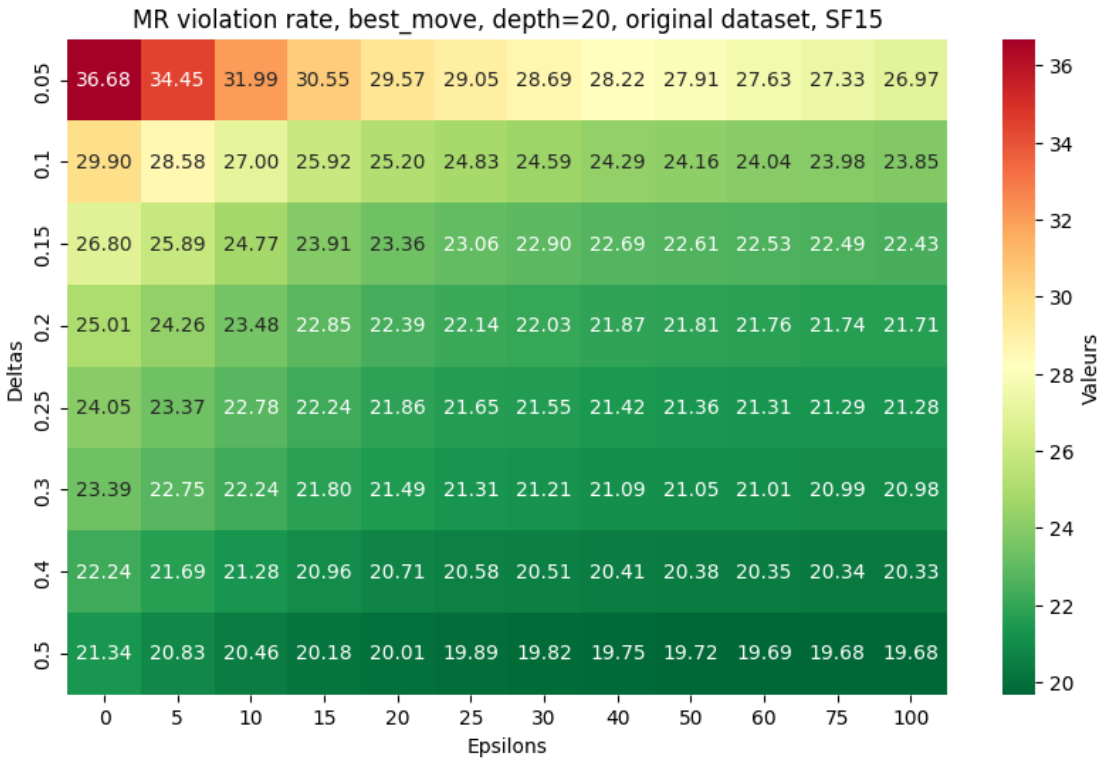
**depth = 15, real positions**

[503]:
```
evaluations50000_best_move_d_15_real =␣
  ↪real_positions(evaluations50000_best_move_d_15[24000:])
evaluations50000_best_move_d_15_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_best_move_d_15_real,4,15, ', original dataset, real␣
  ↪positions, SF15')
```




**depth = 20, entire dataset (Link V16)**

[504]:
```
path = os.path.join('best_move_d=20','evaluations50000_best_move_d_20.pkl')
with open(path, 'rb') as file:
    evaluations50000_best_move_d_20 = pickle.load(file)

tests(evaluations50000_best_move_d_20,4,20, ', original dataset, SF15')
```

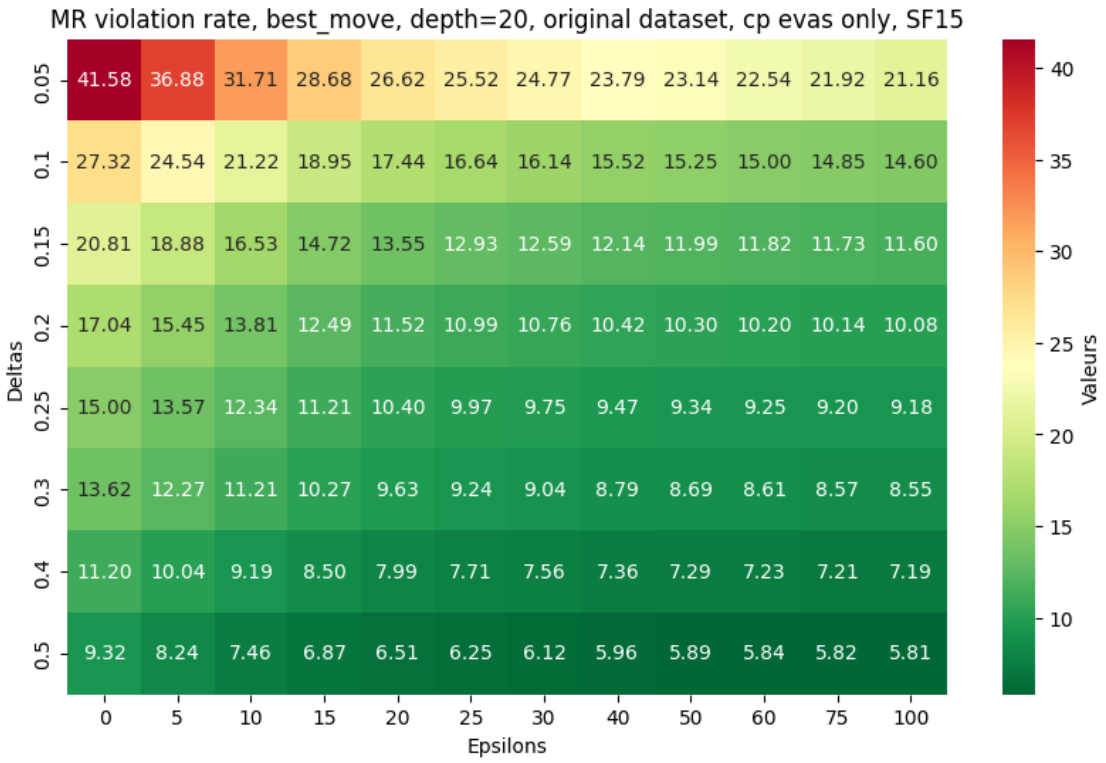



**depth = 20, splitting (Link V16)**

[91]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_best_move_d_20)[1])/
 ↪(len(split_mate_cp(evaluations50000_best_move_d_20)[0])+len(split_mate_cp(evaluations50000_
```

```
Mates proportion :  0.5246750167924453
```

[505]:
```
tests(split_mate_cp(evaluations50000_best_move_d_20)[0],4,20, ', original␣
 ↪dataset, cp evas only, SF15')
```

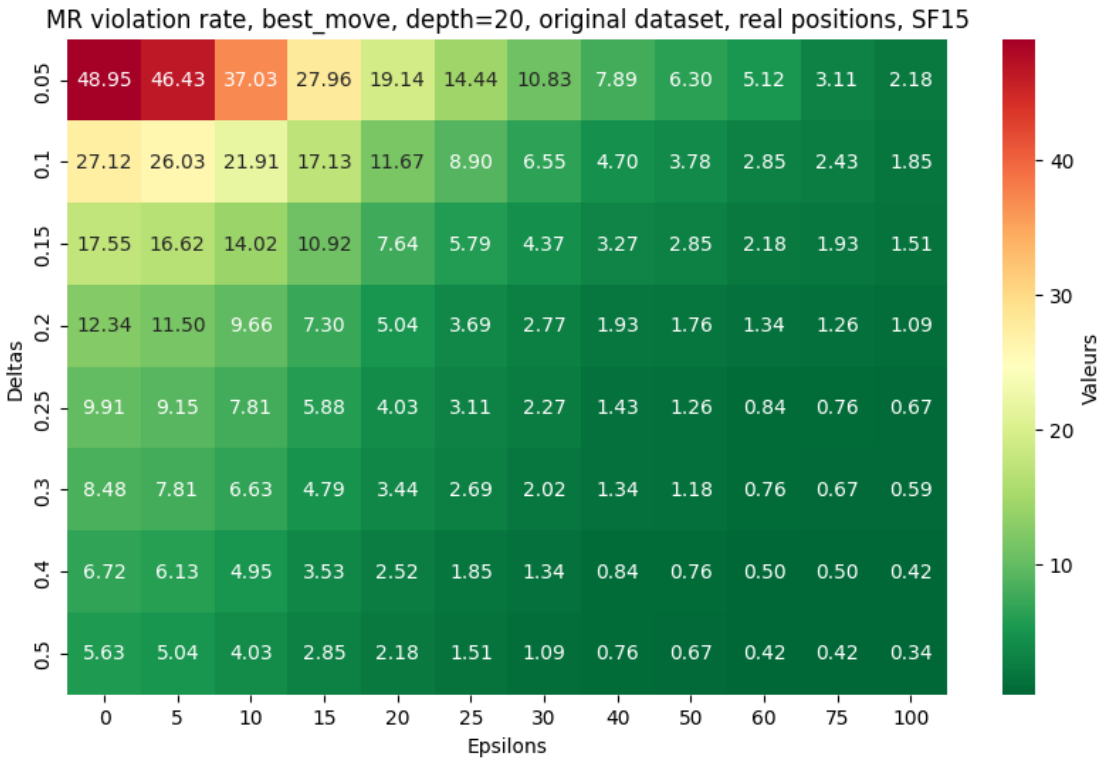



[93]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_best_move_d_20)[1],4,1,1),'%')
```

```
Mates failure rate :  32.23887340914226 %
```

**depth = 20, real positions (Link V16)**

[506]:
```
evaluations50000_best_move_d_20_real =␣
  ↪real_positions(evaluations50000_best_move_d_20[22000:])
evaluations50000_best_move_d_20_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_best_move_d_20_real,4,20, ', original dataset, real␣
  ↪positions, SF15')
```




### 0.8.6 Analysis on biggest gaps

**Additional function** Here is a function to plot evaluations by depth, until the MR is verified and the minimum depth (min_d) is reached. Will stop at max_d if can't verify MR before.

[95]:
```
def plotevas(data1,data2,val,type):
    print('MR verified at depth = ', val)
    ind1 = 0
    ind2 = 0
    cp1 = []
    cp2 = []
    mate1 = []
    mate2 = []
    values1cp = []
    values1mate = []
    values2cp = []
    values2mate = []
    if type == 4:
        for data in data1:
            ind1+=1
            if data.get('Mate') == None:
                cp1.append(ind1)
                values1cp.append(data.get('Centipawn'))
```

```
            else:
                mate1.append(ind1)
                values1mate.append(data.get('Mate'))

        for data in data2:
            ind2+=1
            if data.get('Mate') == None:
                cp2.append(ind2)
                values2cp.append(data.get('Centipawn'))
            else:
                mate2.append(ind2)
                values2mate.append(data.get('Mate'))
    else:
        for data in data1:
            ind1+=1
            if data.get('type') == 'cp':
                cp1.append(ind1)
                values1cp.append(data.get('value'))
            else:
                values1mate.append(data.get('value'))
                mate1.append(ind1)
        for data in data2:
            ind2+=1
            if type == 0:
                if data.get('type') == 'cp':
                    cp2.append(ind2)
                    values2cp.append(data.get('value') * (-1))
                else:
                    mate2.append(ind2)
                    values2mate.append(data.get('value') * (-1))

            else:
                if data.get('type') == 'cp':
                    cp2.append(ind2)
                    values2cp.append(data.get('value'))
                else:
                    mate2.append(ind2)
                    values2mate.append(data.get('value'))


    plt.plot(cp1, values1cp, '-', color='#17d1d3')
    plt.plot(cp2, values2cp, '--',color='#405ee3')

    plt.grid(axis='y', color='#D3D3D3', linestyle='-', linewidth=0.5)


    plt.ylabel('Centipawn advantage', color='blue')
```

```
    plt.tick_params('y', colors='blue')



    plt.twinx()

    plt.plot(mate1, values1mate, '-', color='#f7766d')
    plt.plot(mate2, values2mate, '--', color='#df2c1f')

    plt.ylabel('Mate in', color='red')
    plt.tick_params('y', colors='red')

    plt.show()
```

We are using delta = 0.25 and epsilon = 25 for these tests.

### Stockfish returning opposite evaluations

**sim_mirror, sim_axis** No evidences of really large gaps.

REMINDER : with sim_mirror, since the mutation swap colors, the evaluation of the original position has to match with (-1)*the mutated evaluation.

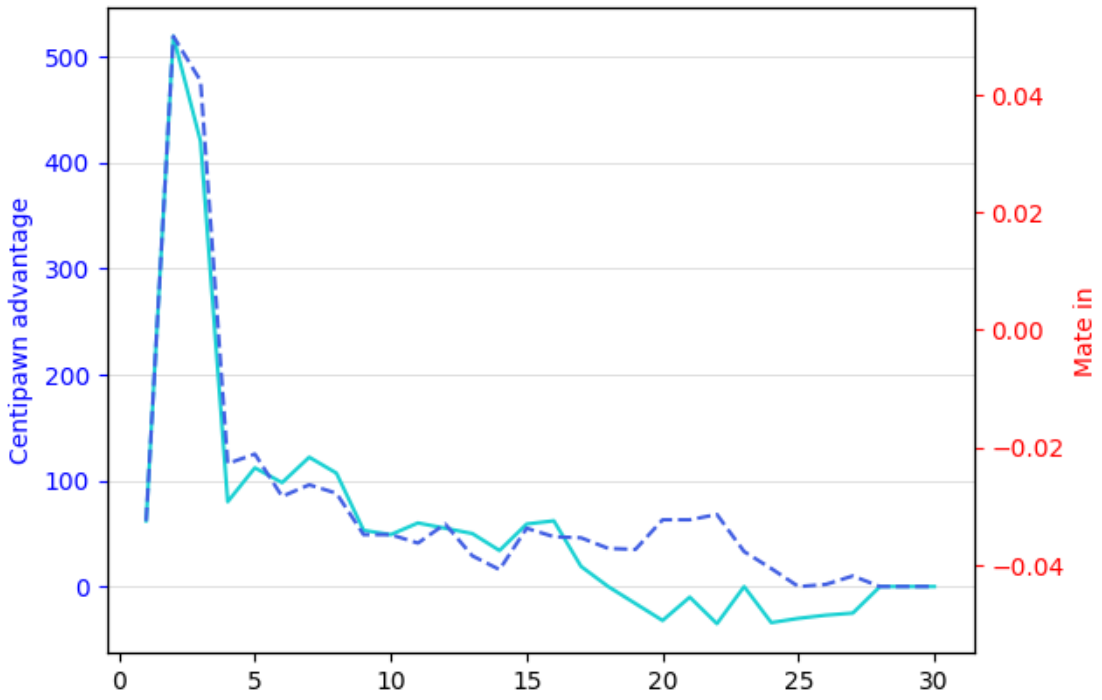
[96]:
```
p8mirror = 'r1b2rk1/p3n1pp/1pn1p3/q1ppPp2/3P4/P1PB1NQ1/2PB1PPP/R3K2R w'

show_pos([p8mirror],300)
print(evaluationdouble(p8mirror,sim_mirror(p8mirror),50000,20))
print(evaluationdouble(p8mirror,sim_axis(p8mirror),50000,20))
```

```
<IPython.core.display.HTML object>
```

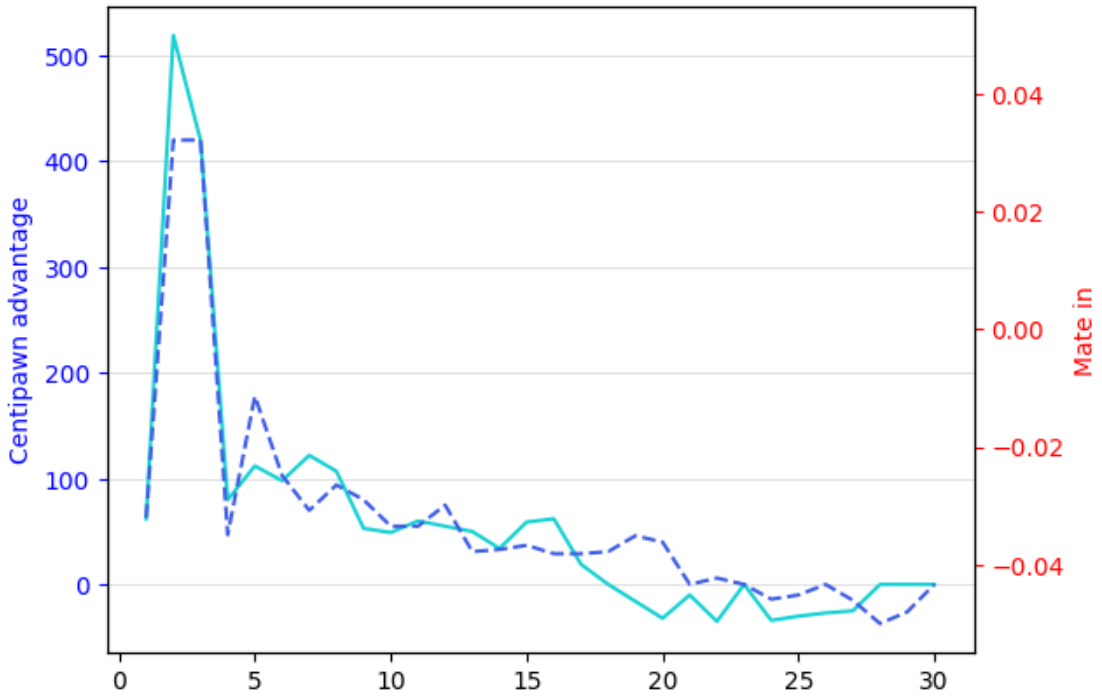
```
({'type': 'cp', 'value': -32}, {'type': 'cp', 'value': -63})
({'type': 'cp', 'value': -32}, {'type': 'cp', 'value': 40})
```

[97]:
```
chemin = os.path.join('plotevas', 'p8mirror.pkl')
with open(chemin, 'rb') as fichier:
    plot8mirror = pickle.load(fichier)

plotevas(plot8mirror[0],plot8mirror[1],plot8mirror[2], 0)

chemin = os.path.join('plotevas', 'p8axis.pkl')
with open(chemin, 'rb') as fichier:
    plot8axis = pickle.load(fichier)

plotevas(plot8axis[0],plot8axis[1],plot8axis[2], 1)
```

```
MR verified at depth =  [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 28,
29, 30]
```




MR verified at depth = [2, 3, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 17, 21, 23, 24, 25, 27, 30]



**best_move**

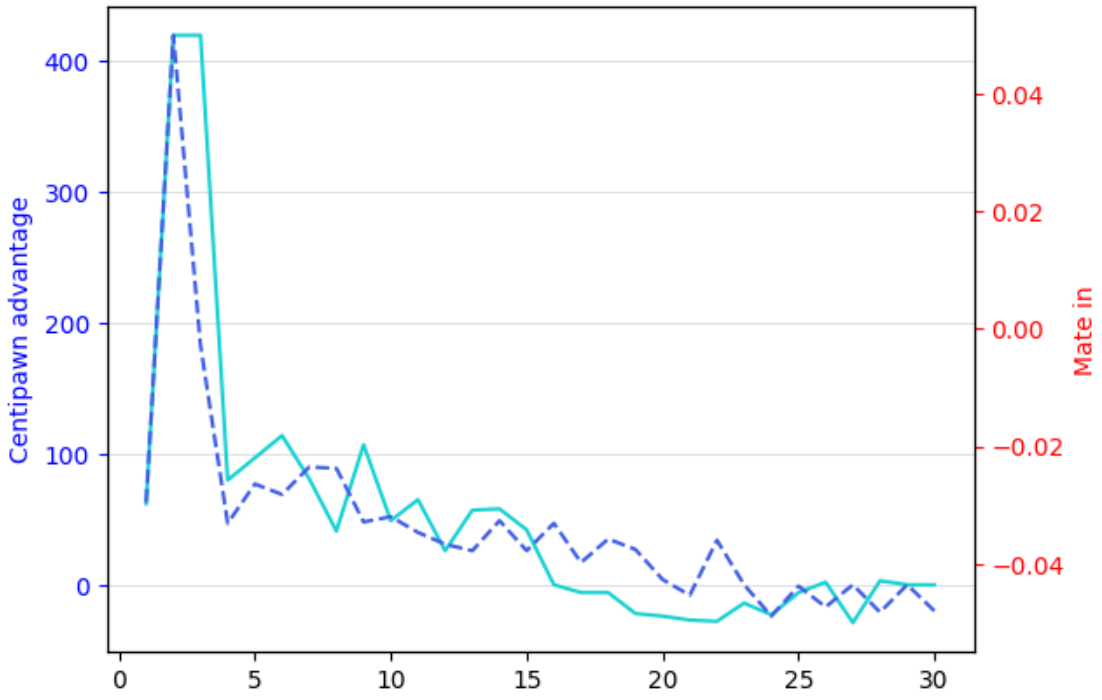
[98]:
```
p1best = 'r2q1rk1/4bppp/3pb3/2n1pP2/1p2P1PP/1P3Q2/1BP1N1B1/2KR3R w'

show_pos([p1best],300)
print(evaluation(p1best,50000,20)[1],evaluation(sim_axis(p1best),50000,20)[1])
```

```
<IPython.core.display.HTML object>
```

```
[{'Move': 'f5e6', 'Centipawn': 74, 'Mate': None}] [{'Move': 'c5d6', 'Centipawn':
-12, 'Mate': None}]
```

[99]:
```
chemin = os.path.join('plotevas', 'p1best.pkl')
with open(chemin, 'rb') as fichier:
    plot1best = pickle.load(fichier)

plotevas(plot1best[0],plot1best[1],plot1best[2], 4)
```

```
MR verified at depth =  [2, 5, 6, 7, 10, 11, 12, 14, 15, 17, 21, 23, 24, 25, 26,
28, 29, 30]
```




**Stockfish having troubles with draw positions at depth = 20**

**sim_mirror**

[100]:
```
p1mirror = '8/8/7k/8/4K3/4r3/2B4P/8 w'
p2mirror = '7b/8/kq6/8/8/1N2R3/K2P4/8 w'

show_pos([p1mirror,p2mirror],300)
print(evaluationdouble(p1mirror,sim_mirror(p1mirror),50000,20))
print(evaluationdouble(p2mirror,sim_mirror(p2mirror),50000,20))
```

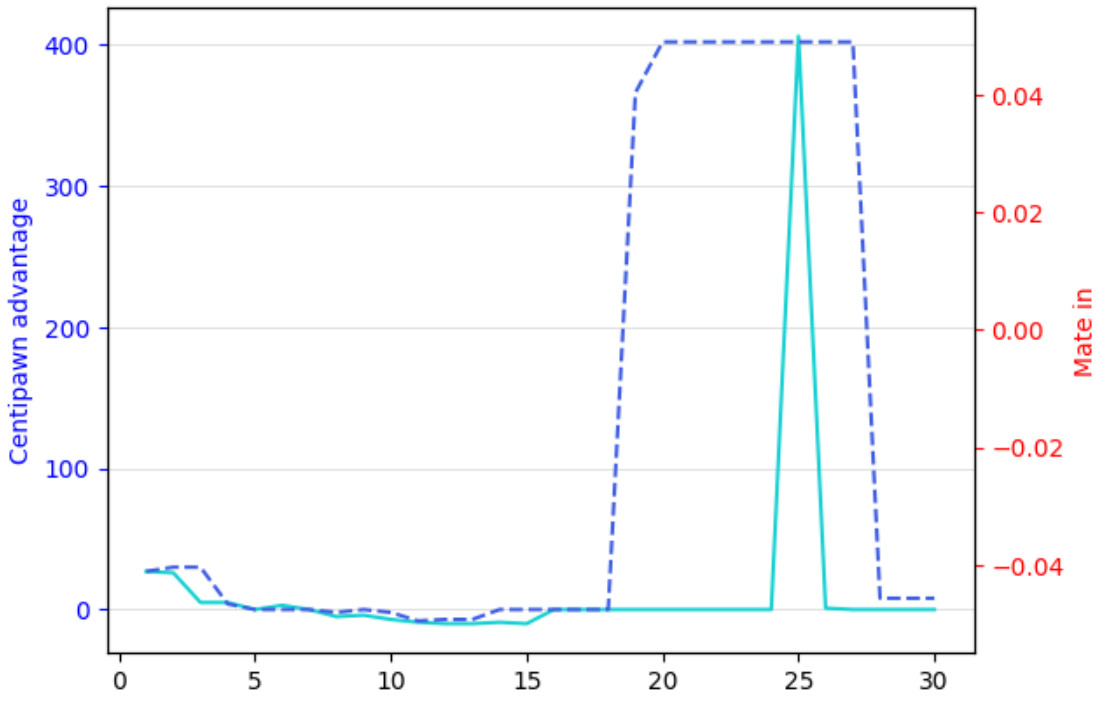
```
<IPython.core.display.HTML object>
```

```
({'type': 'cp', 'value': 0}, {'type': 'cp', 'value': -402})
({'type': 'cp', 'value': -478}, {'type': 'cp', 'value': 0})
```

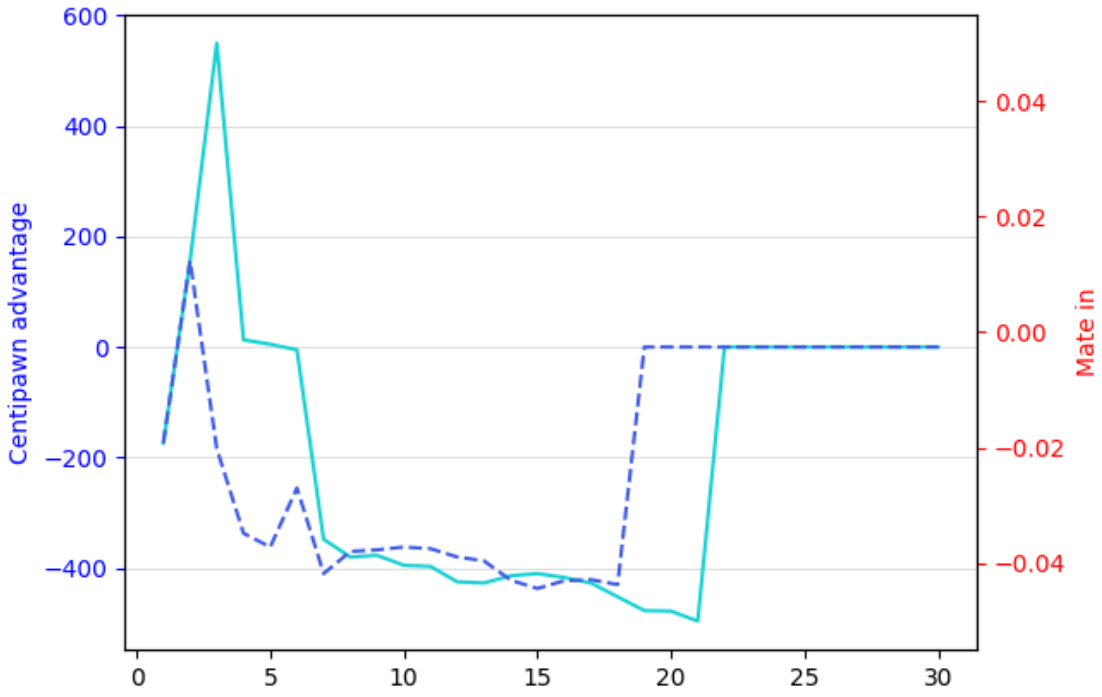
It was in fact verified with a lower depth, but it is verified again with an higher depth. For the first one, it also gets verified at depth 23 with false values.

[101]:
```
chemin = os.path.join('plotevas', 'p1mirror.pkl')
with open(chemin, 'rb') as fichier:
    plot1mirror = pickle.load(fichier)

plotevas(plot1mirror[0],plot1mirror[1],plot1mirror[2], 0)

chemin = os.path.join('plotevas', 'p2mirror.pkl')
with open(chemin, 'rb') as fichier:
    plot2mirror = pickle.load(fichier)


plotevas(plot2mirror[0],plot2mirror[1],plot2mirror[2], 0)
```

```
MR verified at depth =  [2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17,
18, 25, 28, 29, 30]
```




MR verified at depth = [2, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 22, 23, 24, 25, 26, 27, 28, 29, 30]



**sim_axis, sim_diag**

[102]:
```
print(evaluationdouble(p1mirror,sim_axis(p1mirror),50000,20))
print(evaluationdouble(p2mirror,sim_axis(p2mirror),50000,20))

print(evaluationdouble(p1mirror,sim_diag(p1mirror),50000,20))
print(evaluationdouble(p2mirror,sim_diag(p2mirror),50000,20))

print(evaluation(p1mirror,50000,20)[1],evaluation(sim_axis(p1mirror),50000,20)[1])
print(evaluation(p2mirror,50000,20)[1],evaluation(sim_axis(p2mirror),50000,20)[1])
```

```
({'type': 'cp', 'value': 0}, {'type': 'cp', 'value': 0})
({'type': 'cp', 'value': -478}, {'type': 'cp', 'value': -477})
({'type': 'cp', 'value': 0}, {'type': 'cp', 'value': 0})
({'type': 'cp', 'value': -478}, {'type': 'cp', 'value': -698})
[{'Move': 'e4e3', 'Centipawn': 0, 'Mate': None}] [{'Move': 'd4d3', 'Centipawn':
0, 'Mate': None}]
[{'Move': 'a2b1', 'Centipawn': -501, 'Mate': None}] [{'Move': 'h2g1',
'Centipawn': -498, 'Mate': None}]
```

Stockfish doesn't fail on the two previous position in sim_axis. Couldn't find other examples.

**Stockfish showing gaps in evaluation on non-draw positions at depth = 20**

**sim_mirror**

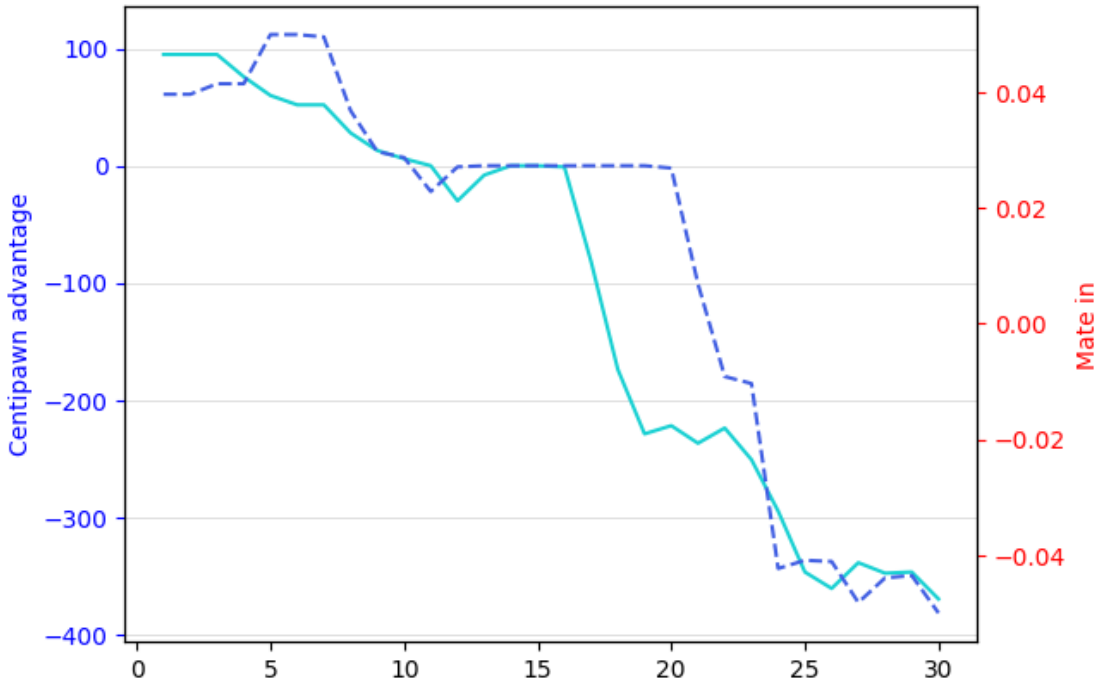
[103]:
```
p3mirror = '8/K7/3N4/2PR2r1/n2k4/3p3N/4Pn2/6B1 b'
p4mirror = '8/2p1k3/3p3p/2PP1pp1/1P1K1P2/6P1/8/8 w'
show_pos([p3mirror,p4mirror],300)

print(evaluationdouble(p3mirror,sim_mirror(p3mirror),50000,20))
print(evaluationdouble(p4mirror,sim_mirror(p4mirror),50000,20))
```

```
<IPython.core.display.HTML object>
```

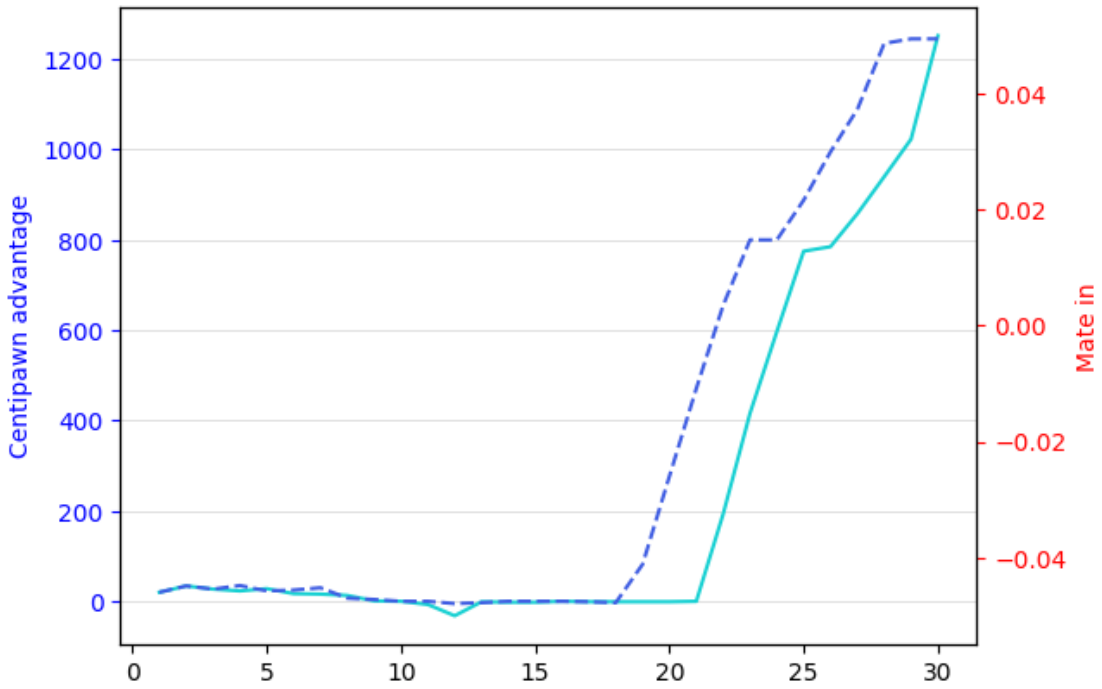
```
({'type': 'cp', 'value': -222}, {'type': 'cp', 'value': 2})
({'type': 'cp', 'value': -1}, {'type': 'cp', 'value': -277})
```

[104]:
```
chemin = os.path.join('plotevas', 'p3mirror.pkl')
with open(chemin, 'rb') as fichier:
    plot3mirror = pickle.load(fichier)

plotevas(plot3mirror[0],plot3mirror[1],plot3mirror[2], 0)

chemin = os.path.join('plotevas', 'p4mirror.pkl')
with open(chemin, 'rb') as fichier:
    plot4mirror = pickle.load(fichier)

plotevas(plot4mirror[0],plot4mirror[1],plot3mirror[2], 0)
```

MR verified at depth = [2, 3, 4, 8, 9, 10, 11, 13, 14, 15, 16, 22, 23, 24, 25, 26, 27, 28, 29, 30]




MR verified at depth = [2, 3, 4, 8, 9, 10, 11, 13, 14, 15, 16, 22, 23, 24, 25, 26, 27, 28, 29, 30]




Stockfish shows a similar behaviour with the second position when using sim_axis.

**sim_axis**

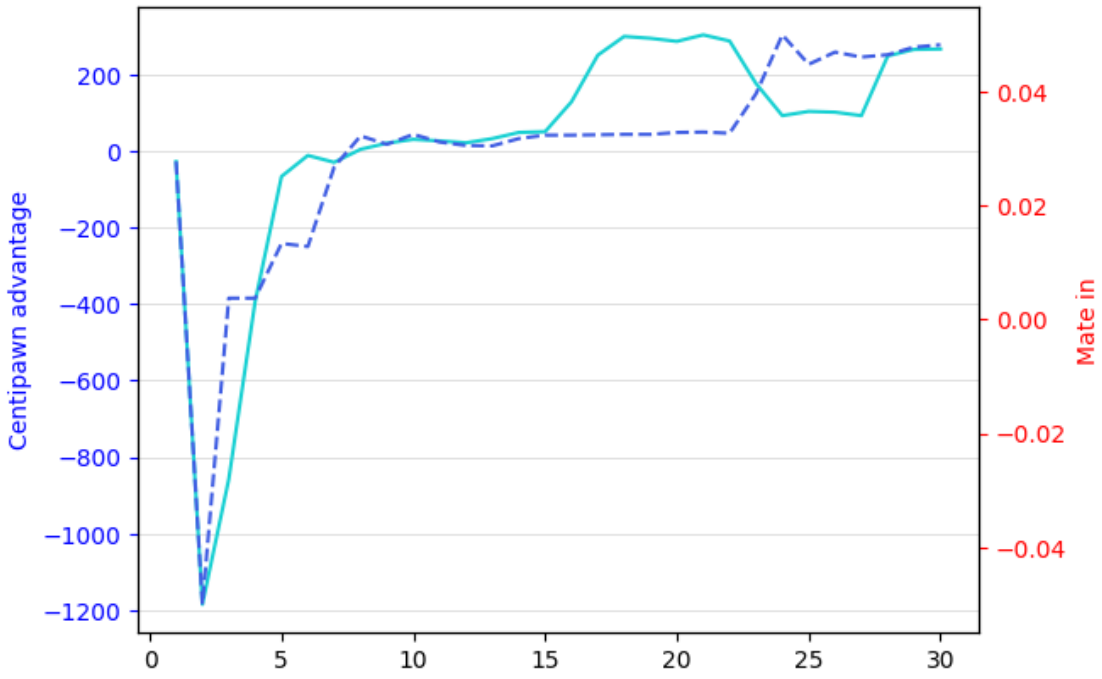
[105]:
```
p3axis = '1K6/3R2kr/8/8/8/BQ5r/2b1r3/5n2 b'
p2axis = 'rn1qr1k1/1p2bppp/p3p3/3pP3/P2P1B2/2RB1Q1P/1P3PP1/R5K1 w'
show_pos([p3axis,p2axis],300)

print(evaluationdouble(p3axis,sim_axis(p3axis),50000,20))
print(evaluationdouble(p2axis,sim_axis(p2axis),50000,20))
```

```
<IPython.core.display.HTML object>

({'type': 'cp', 'value': 286}, {'type': 'cp', 'value': 48})
({'type': 'cp', 'value': 129}, {'type': 'cp', 'value': 344})
```

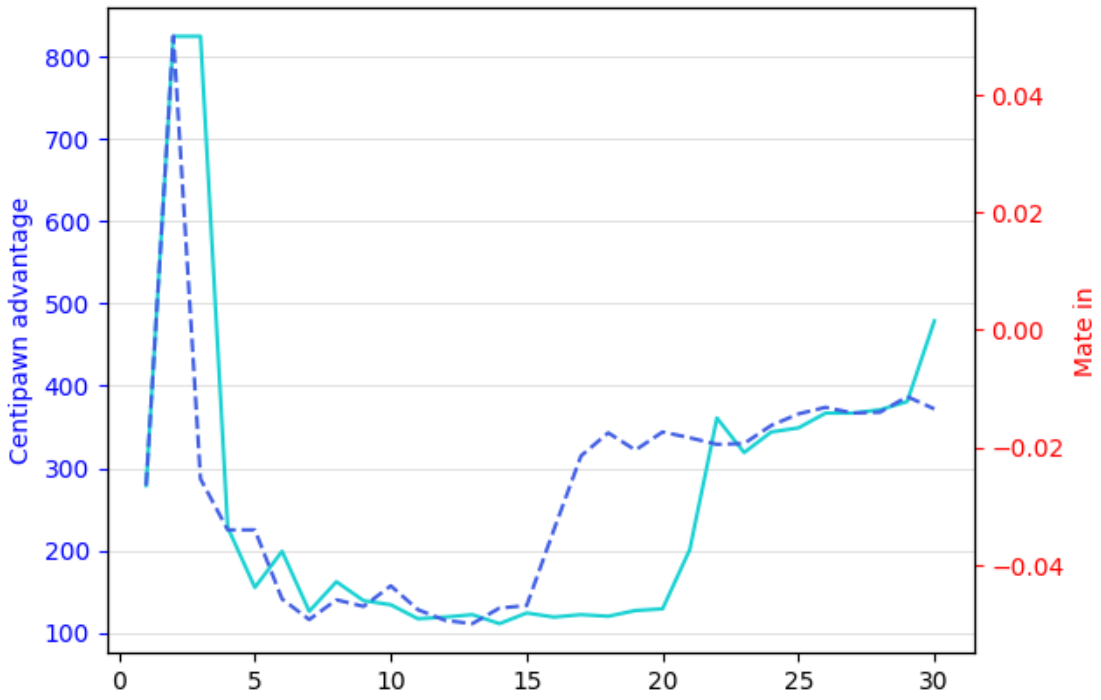
[106]:
```
chemin = os.path.join('plotevas', 'p3axis.pkl')
with open(chemin, 'rb') as fichier:
    plot3axis = pickle.load(fichier)

plotevas(plot3axis[0],plot3axis[1],plot3axis[2], 1)

chemin = os.path.join('plotevas', 'p2axis.pkl')
with open(chemin, 'rb') as fichier:
    plot2axis = pickle.load(fichier)
```

```
plotevas(plot2axis[0],plot2axis[1],plot2axis[2], 1)
```

```
MR verified at depth =  [2, 4, 7, 9, 10, 11, 12, 13, 14, 15, 23, 28, 29, 30]
```




```
MR verified at depth =  [2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 22, 23,
24, 25, 26, 27, 28, 29, 30]
```



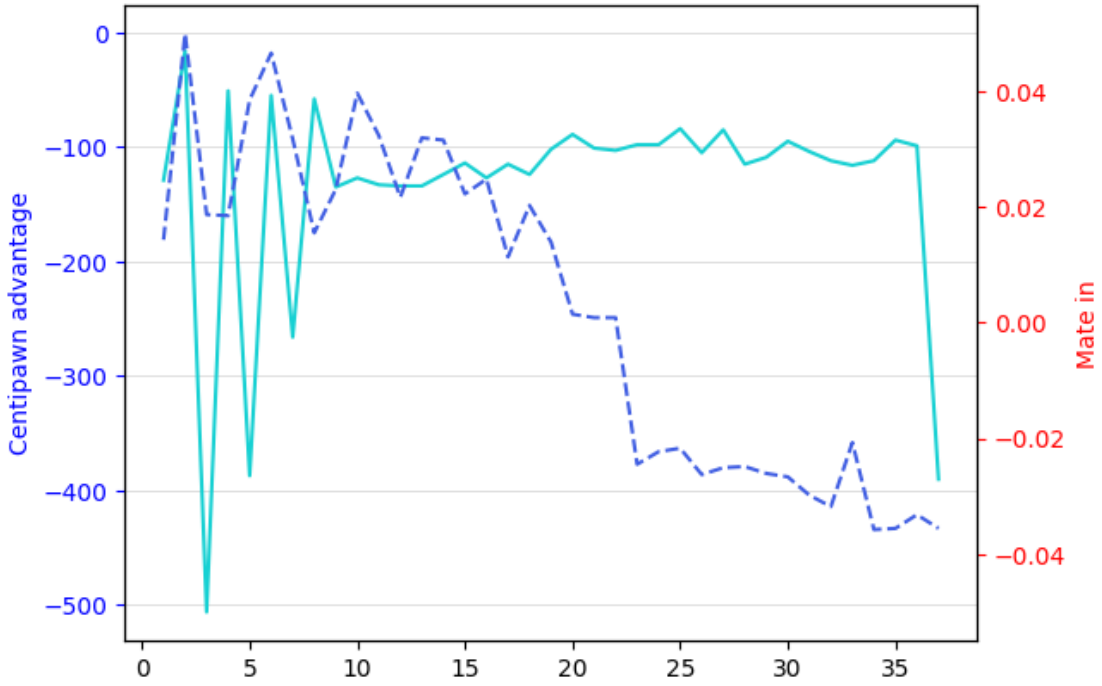

**sim_diag**

[107]:
```
p3diag = 'N7/8/1n6/3B4/4r3/4k3/2K5/6r1 w '
p2diag = '8/8/8/n3N3/2Q1r3/5k2/1K6/8 b'
show_pos([p3diag,p2diag],300)

print(evaluationdouble(p3diag,sim_diag(p3diag),50000,20))
print(evaluationdouble(p2diag,sim_diag(p2diag),50000,20))
```

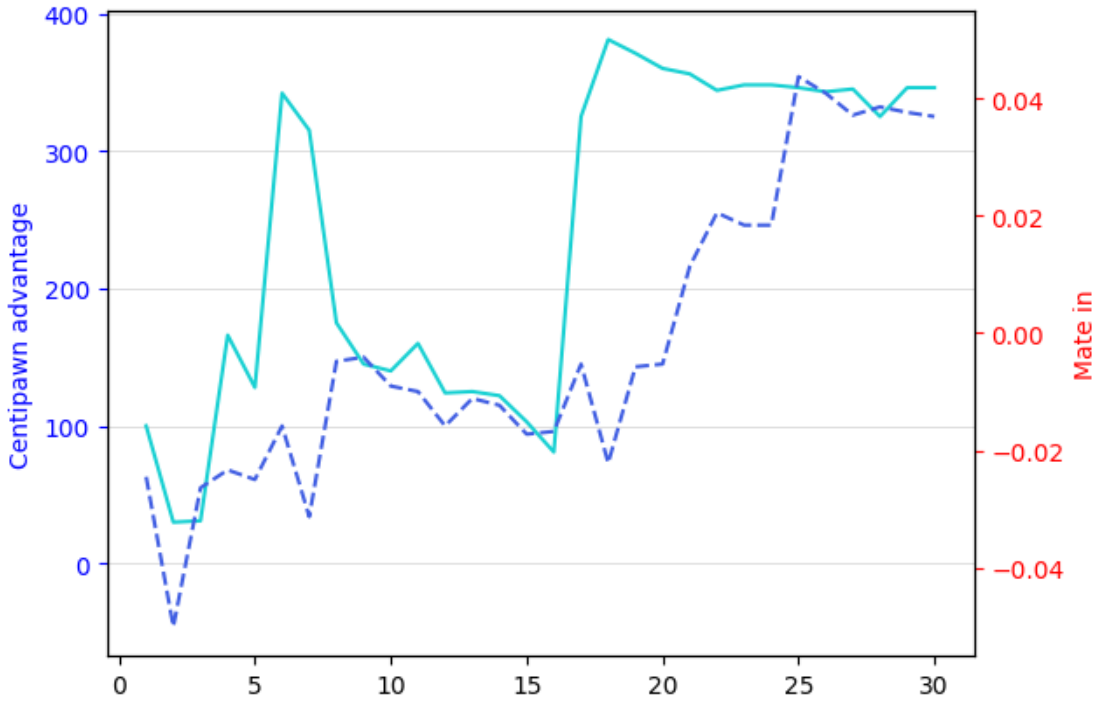
```
<IPython.core.display.HTML object>

({'type': 'cp', 'value': -89}, {'type': 'cp', 'value': -246})
({'type': 'cp', 'value': 360}, {'type': 'cp', 'value': 145})
```

[108]:
```
chemin = os.path.join('plotevas', 'p3diag.pkl')
with open(chemin, 'rb') as fichier:
    plot3diag = pickle.load(fichier)

plotevas(plot3diag[0],plot3diag[1],plot3diag[2], 2)

chemin = os.path.join('plotevas', 'p2diag.pkl')
with open(chemin, 'rb') as fichier:
    plot2diag = pickle.load(fichier)

plotevas(plot2diag[0],plot2diag[1],plot2diag[2], 2)
```

MR verified at depth = [2, 9, 11, 12, 13, 14, 15, 16, 18, 37]




MR verified at depth = [3, 8, 9, 10, 11, 12, 13, 14, 15, 16, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30]



**best_move**

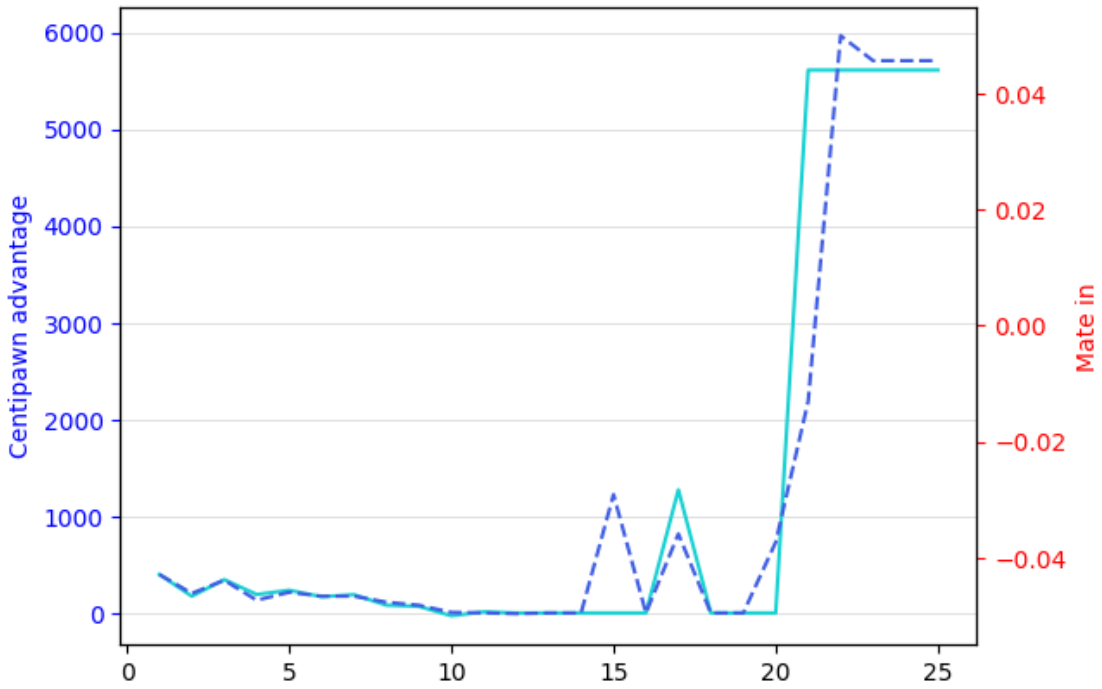
[109]:
```
p2best = '8/1BK5/8/1pk5/8/8/5P2/8 b'
p3best = '4K3/1P6/4Rqk1/6B1/4N2N/2q3r1/b1np4/8 b'
show_pos([p2best,p3best],300)

print(evaluation(p2best,50000,20)[1],evaluation(sim_axis(p2best),50000,20)[1])
print(evaluation(p3best,50000,20)[1],evaluation(sim_axis(p3best),50000,20)[1])
```

```
<IPython.core.display.HTML object>
```

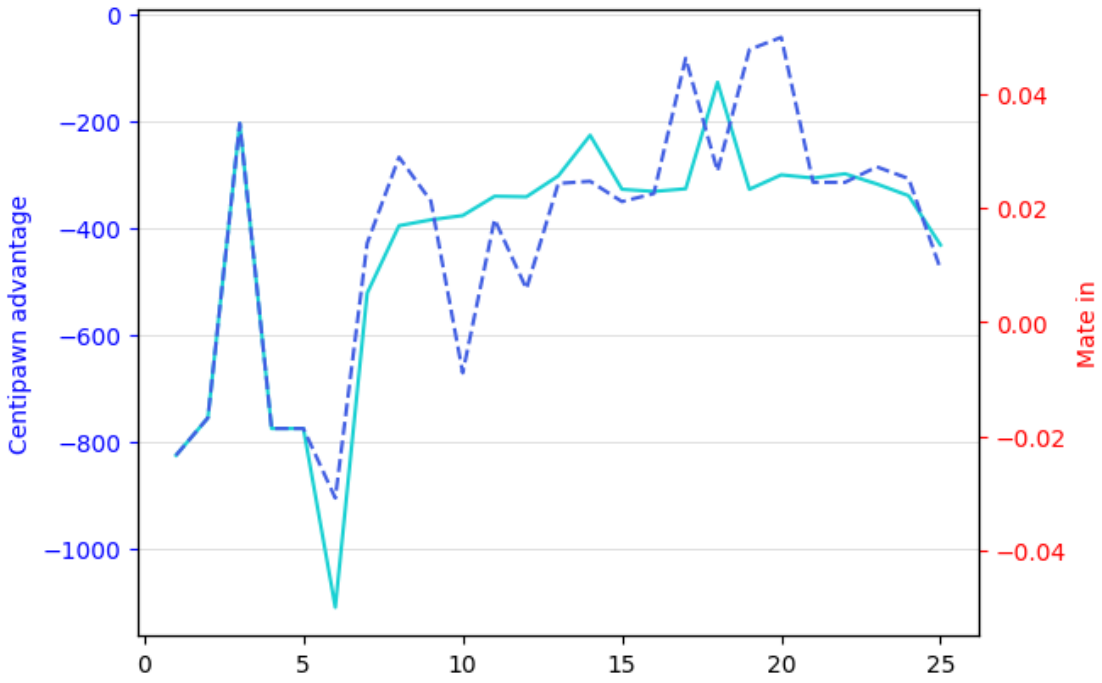
```
[{'Move': 'b5b4', 'Centipawn': 0, 'Mate': None}] [{'Move': 'g5g4', 'Centipawn':
731, 'Mate': None}]
[{'Move': 'g6h5', 'Centipawn': -300, 'Mate': None}] [{'Move': 'b6a5',
'Centipawn': -43, 'Mate': None}]
```

[110]:
```
chemin = os.path.join('plotevas', 'p2best.pkl')
with open(chemin, 'rb') as fichier:
    plot2best = pickle.load(fichier)

plotevas(plot2best[0],plot2best[1],plot2best[2], 4)

chemin = os.path.join('plotevas', 'p3best.pkl')
with open(chemin, 'rb') as fichier:
    plot3best = pickle.load(fichier)

plotevas(plot3best[0],plot3best[1],plot3best[2], 4)
```

```
MR verified at depth =  [2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, 19,
22, 23, 24, 25]
```




MR verified at depth = [2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 21, 22, 23, 24, 25]



**Stockfish fails to get the same mate value at depth = 20 on positions**

**sim_mirror**

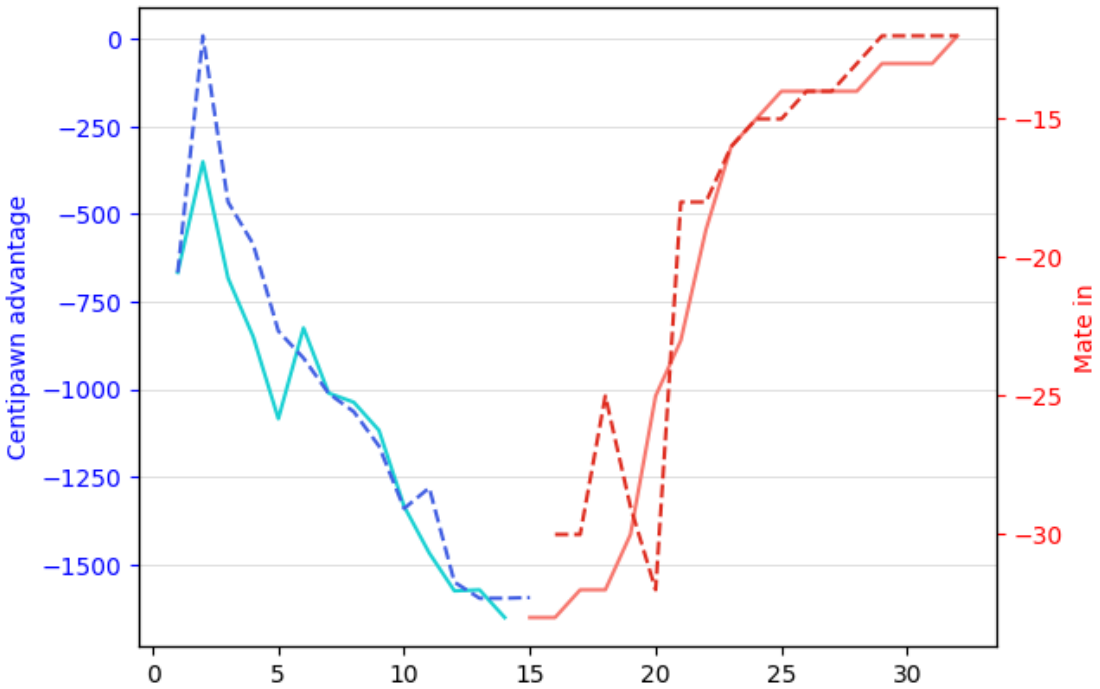
[111]:
```
p5mirror = '3b4/6k1/8/8/4N3/8/q7/2K1Rn2 w'
show_pos([p5mirror],300)
print(evaluationdouble(p5mirror,sim_mirror(p5mirror),50000,20))
```

```
<IPython.core.display.HTML object>
```

```
({'type': 'mate', 'value': -25}, {'type': 'mate', 'value': 32})
```

[112]:
```
chemin = os.path.join('plotevas', 'p5mirror.pkl')
with open(chemin, 'rb') as fichier:
    plot5mirror = pickle.load(fichier)

plotevas(plot5mirror[0],plot5mirror[1],plot5mirror[2], 0)
```

```
MR verified at depth =  [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 23, 24, 26,
27, 32]
```




**sim_axis**

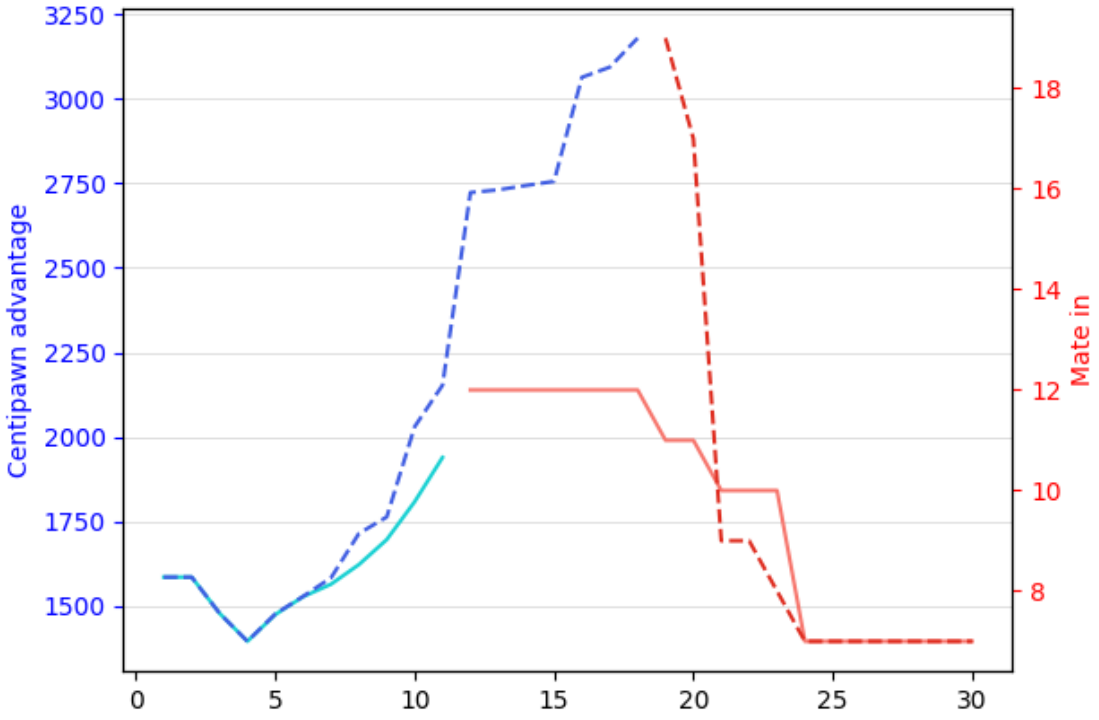
[113]:
```
p4axis = '3N4/8/B3k3/1RK2B2/8/8/4P2r/6B1 b'
show_pos([p4axis],300)
print(evaluationdouble(p4axis,sim_axis(p4axis),50000,20))
```

```
<IPython.core.display.HTML object>
```

```
({'type': 'mate', 'value': 11}, {'type': 'mate', 'value': 17})
```

[114]:
```
chemin = os.path.join('plotevas', 'p4axis.pkl')
with open(chemin, 'rb') as fichier:
    plot4axis = pickle.load(fichier)

plotevas(plot4axis[0],plot4axis[1],plot4axis[2], 1)
```

```
MR verified at depth =  [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 24, 25, 26, 27, 28, 29,
30]
```



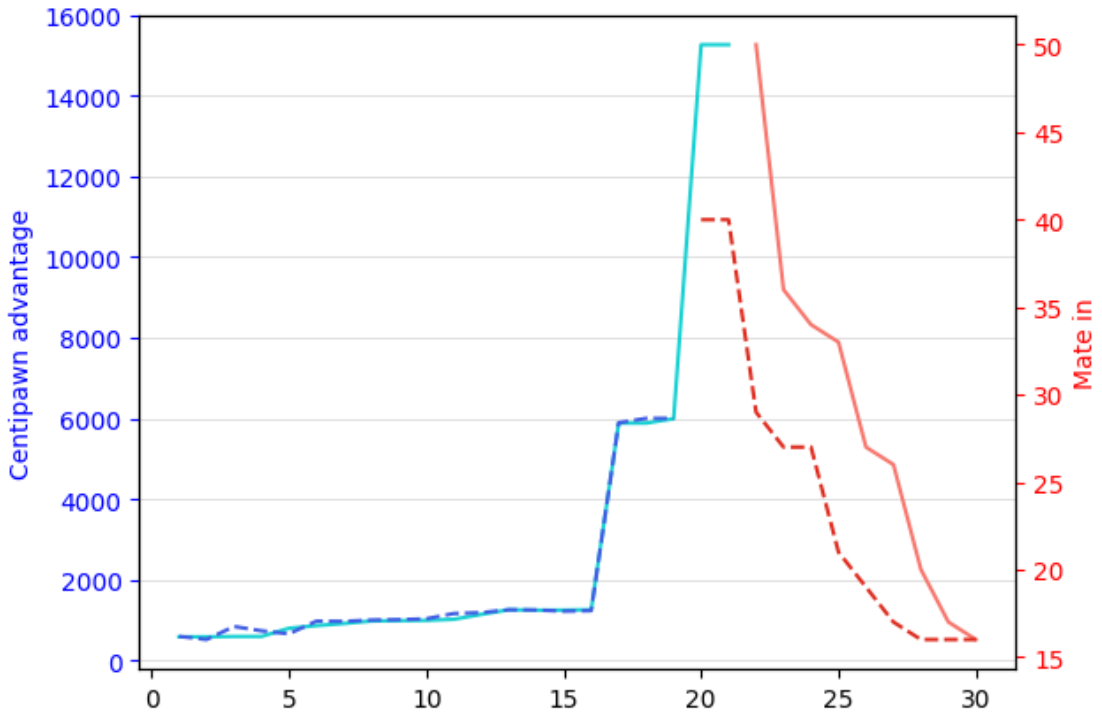

**sim_diag**

[115]:
```
p4diag = '8/1nK5/6k1/8/6n1/8/8/4B1Qn b'
show_pos([p4diag],300)
print(evaluationdouble(p4diag,sim_diag(p4diag),50000,20))
```

```
<IPython.core.display.HTML object>

({'type': 'cp', 'value': 15265}, {'type': 'mate', 'value': 40})
```

[116]:
```
chemin = os.path.join('plotevas', 'p4diag.pkl')
with open(chemin, 'rb') as fichier:
    plot4diag = pickle.load(fichier)

plotevas(plot4diag[0],plot4diag[1],plot4diag[2], 2)
```

```
MR verified at depth =  [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17,
18, 19, 30]
```




**best_move**

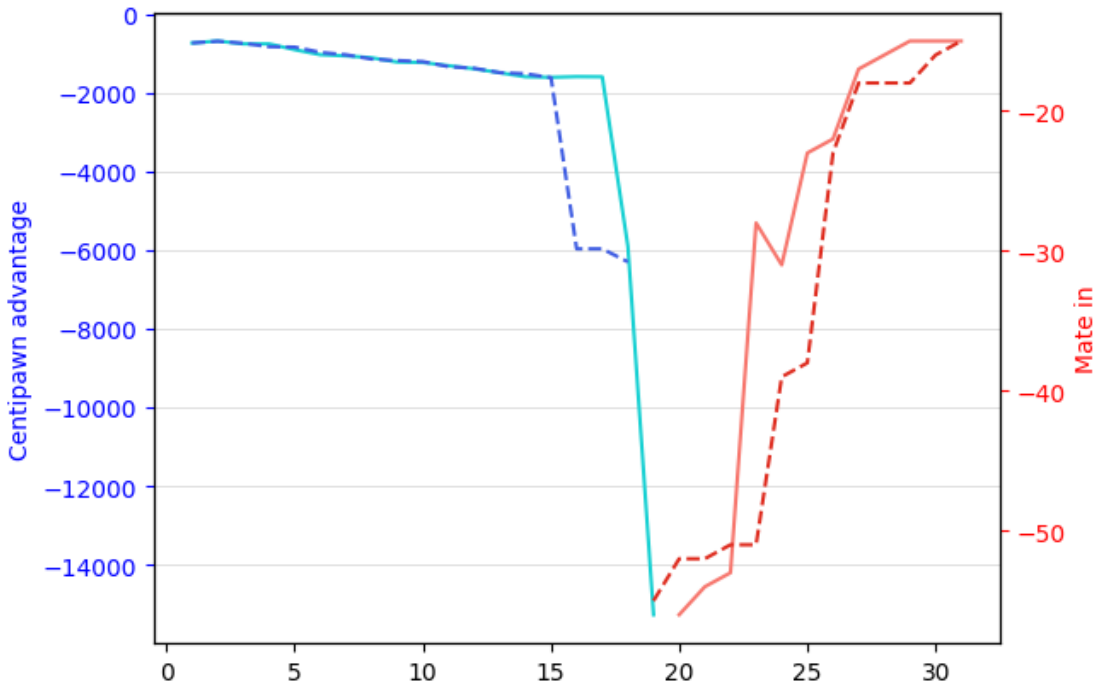
[117]:
```
p4best = '1n6/8/8/8/1K6/5pP1/3P1n2/2k5 w'
show_pos([p4best],300)

print(evaluation(p4best,50000,20)[1],evaluation(sim_axis(p4best),50000,20)[1])
```

```
<IPython.core.display.HTML object>
```

```
[{'Move': 'd2d4', 'Centipawn': None, 'Mate': -56}] [{'Move': 'e2e4',
'Centipawn': None, 'Mate': -52}]
```

[118]:
```
chemin = os.path.join('plotevas', 'p4best.pkl')
with open(chemin, 'rb') as fichier:
    plot4best = pickle.load(fichier)

plotevas(plot4best[0],plot4best[1],plot4best[2], 4)
```

```
MR verified at depth =  [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 31]
```




**Stockfish behaviour with near-mate positions**

**sim_mirror**

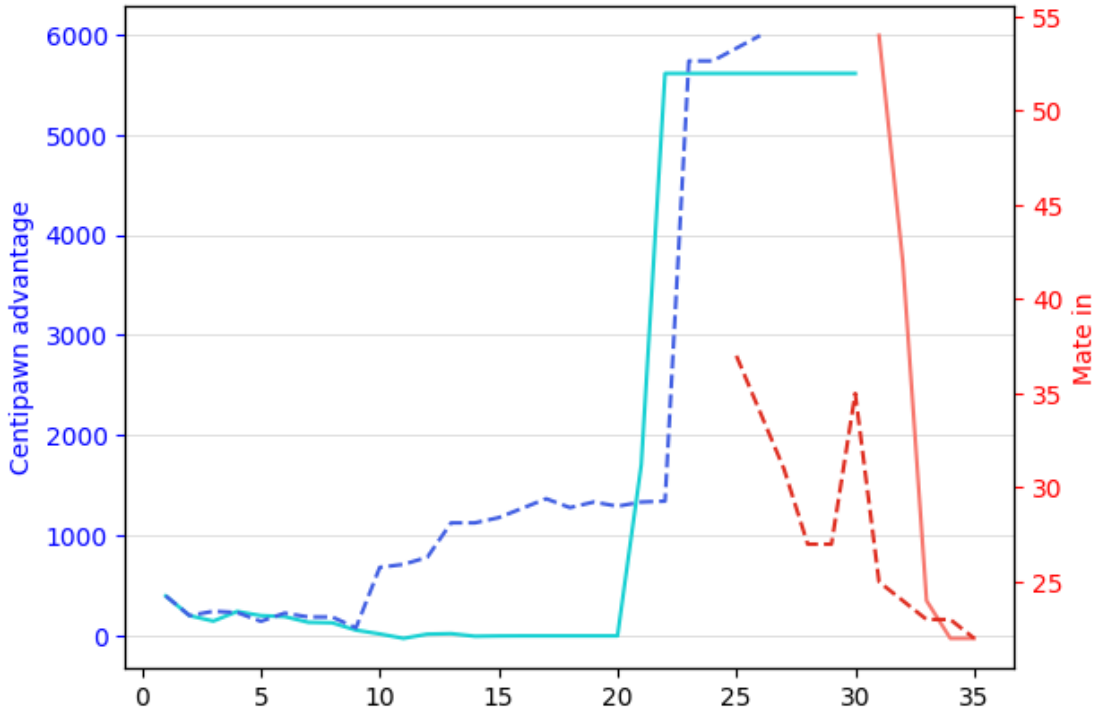
[119]:
```
p6mirror = '8/1BK5/8/1pk5/8/8/5P2/8 b'
p7mirror = '3K4/8/7N/6n1/8/3k4/3p4/8 w'
show_pos([p6mirror,p7mirror],300)
print(evaluationdouble(p6mirror,sim_mirror(p6mirror),50000,20))
print(evaluationdouble(p7mirror,sim_mirror(p7mirror),50000,20))
```

```
<IPython.core.display.HTML object>
```

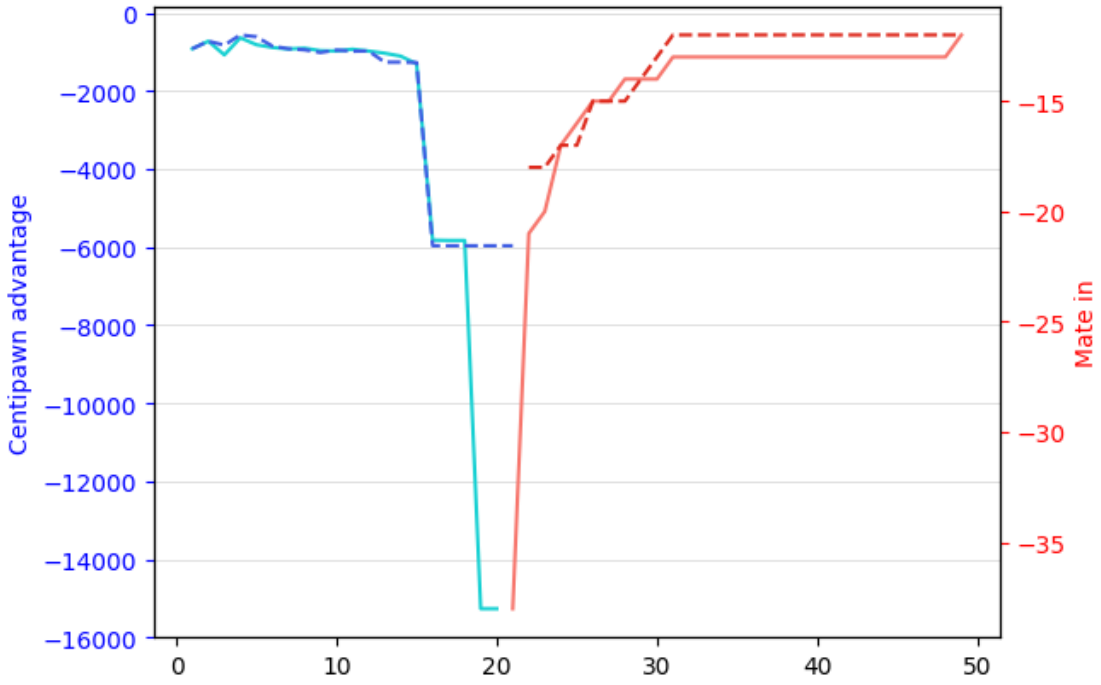
```
({'type': 'cp', 'value': 0}, {'type': 'cp', 'value': -1293})
({'type': 'cp', 'value': -15265}, {'type': 'cp', 'value': 5964})
```

[120]:
```
chemin = os.path.join('plotevas', 'p6mirror.pkl')
with open(chemin, 'rb') as fichier:
    plot6mirror = pickle.load(fichier)

plotevas(plot6mirror[0],plot6mirror[1],plot6mirror[2], 0)

chemin = os.path.join('plotevas', 'p7mirror.pkl')
with open(chemin, 'rb') as fichier:
    plot7mirror = pickle.load(fichier)

plotevas(plot7mirror[0],plot7mirror[1],plot7mirror[2], 0)
```

MR verified at depth = [2, 3, 4, 5, 6, 7, 8, 9, 21, 23, 24, 26, 35]




MR verified at depth = [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 24, 26, 27, 29, 49]



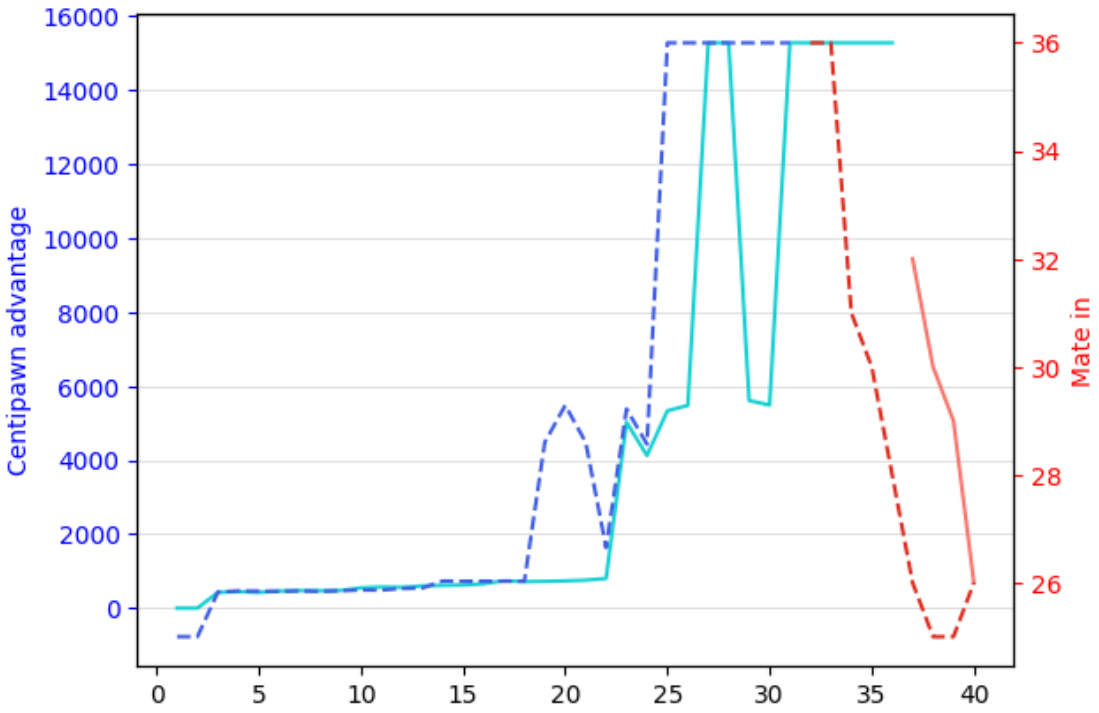
**sim_axis**

[121]:
```
p5axis = '3RR3/6k1/K7/8/8/7r/8/8 b'
show_pos([p5axis],300)
print(evaluationdouble(p5axis,sim_axis(p5axis),50000,20))
```

```
<IPython.core.display.HTML object>

({'type': 'cp', 'value': 740}, {'type': 'cp', 'value': 5480})
```

[122]:
```
chemin = os.path.join('plotevas', 'p5axis.pkl')
with open(chemin, 'rb') as fichier:
    plot5axis = pickle.load(fichier)

plotevas(plot5axis[0],plot5axis[1],plot5axis[2], 1)
```

```
MR verified at depth =  [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17,
18, 23, 24, 27, 28, 31, 40]
```




It eventually converges at a certain point.

**sim_diag**

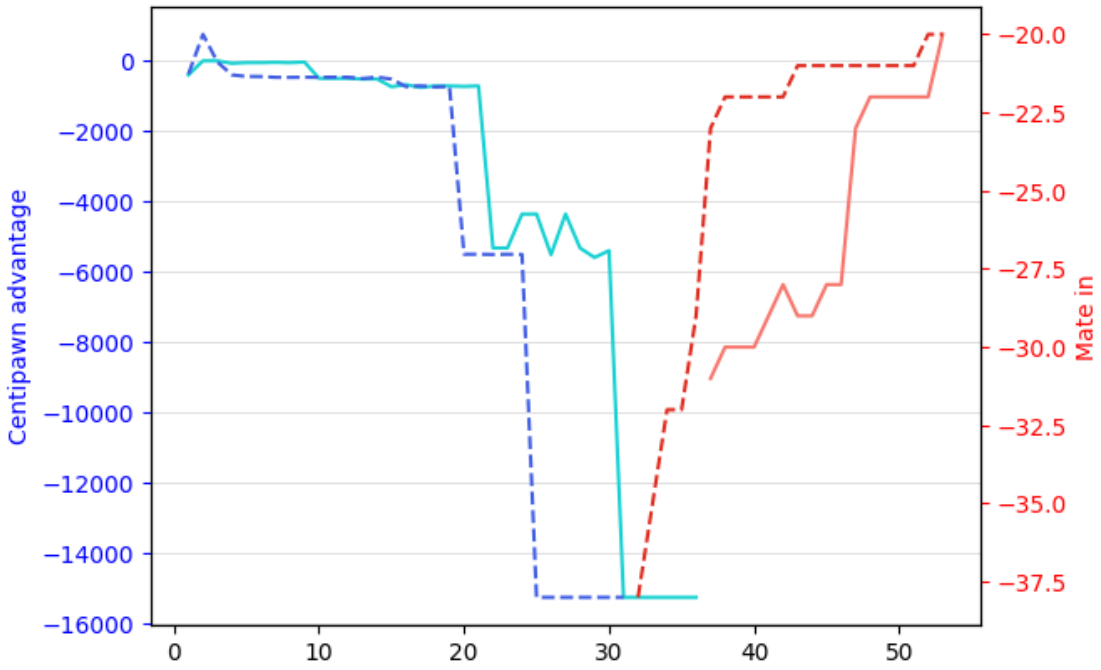
[123]:
```
p5diag = '3r4/8/8/R2K4/8/8/2N3r1/5k2 w'
show_pos([p5diag],300)
print(evaluationdouble(p5diag,sim_diag(p5diag),50000,20))
```

```
<IPython.core.display.HTML object>
```

```
({'type': 'cp', 'value': -727}, {'type': 'cp', 'value': -5502})
```

[124]:
```
chemin = os.path.join('plotevas', 'p5diag.pkl')
with open(chemin, 'rb') as fichier:
    plot5diag = pickle.load(fichier)

plotevas(plot5diag[0],plot5diag[1],plot5diag[2], 2)
```

```
MR verified at depth =  [10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 22, 23, 24, 31,
53]
```




**best_move**

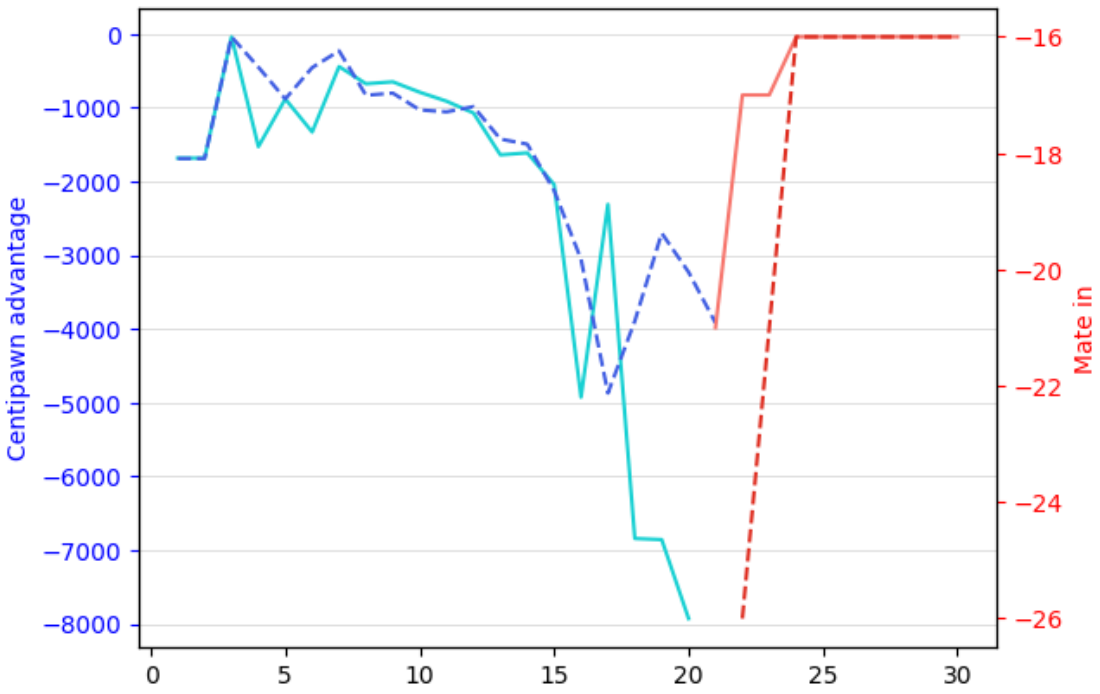
[287]:
```
p5best = 'q1B1R3/2k4R/8/pP6/2B5/r4q2/1R1B4/1K2R2q b'
show_pos([p5best,sim_axis(p5best)],300)
print(evaluation(p5best,50000,20)[1],evaluation(sim_axis(p5best),50000,20)[1])
```

```
<IPython.core.display.HTML object>
```

```
[{'Move': 'h1h7', 'Centipawn': -7925, 'Mate': None}] [{'Move': 'a1a7',
'Centipawn': -3229, 'Mate': None}]
```

[126]:
```
chemin = os.path.join('plotevas', 'p5best.pkl')
with open(chemin, 'rb') as fichier:
    plot5best = pickle.load(fichier)

plotevas(plot5best[0],plot5best[1],plot5best[2], 4)
```

```
MR verified at depth =  [2, 3, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 24, 25, 26,
27, 28, 29, 30]
```




## 0.9 Tests on the Carlsen-Nepo game

The article used the MR_mirror on the 20 first positions of a Carlsen-Nepo game, and it was violated on 4 positions. Experience is reproduced below.

[126]:
```
def carlsen_nepo_analysis(depth,v):
    if v==15:
        stockfish = Stockfish('stockfish_15_x64_avx2.exe')
    if v==16:
        stockfish = Stockfish('stockfish-windows-x86-64-avx2')
    stockfish.set_elo_rating(50000)
    stockfish.set_depth(depth)
    moves1 =␣
 ↪['d2d4','g8f6','g1f3','d7d5','g2g3','e7e6','f1g2','f8e7','e1g1','e8g8','b2b3','c7c5','d4c5'
    index = 0
    indexy = []
```

```
    pos1s = []
    pos2s =  []
    ev1s = []
    ev2s = []
    MR = []
    epsilons = []
    deltas = []
    for move in moves1:
        indexy.append(index)
        print(index, end='', flush=True)
        print('\r', end='', flush=True)
        stockfish.make_moves_from_current_position([move])
        pos1s.append(stockfish.get_fen_position())
        ev1s.append(stockfish.get_evaluation())
        index+=1
    stockfish.set_fen_position('rnbqkbnr/pppppppp/8/8/8/8/PPPPPPPP/RNBQKBNR b␣
↪KQkq - 0 1')
    print('   II', end='', flush=True)
    print('\r', end='', flush=True)
    moves2 =␣
↪['d7d5','g1f3','g8f6','d2d4','g7g6','e2e3','f8g7','f1e2','e8g8','e1g1','b7b6','c2c4','d5c4'
    index = 0
    for move in moves2:
        print(index, end='', flush=True)
        print('\r', end='', flush=True)
        stockfish.make_moves_from_current_position([move])
        pos2s.append(stockfish.get_fen_position())
        ev2s.append(stockfish.get_evaluation())
        index+=1
    for k in range(len(pos1s)):
        MR.append(MR_mirror(ev1s[k],ev2s[k],0.25,25))
        epsilons.append(abs(ev1s[k].get('value')+ev2s[k].get('value')))
        if ev1s[k].get('value')==0 and ev2s[k].get('value')==0:
            deltas.append(0)
        else:
            deltas.append(round(abs(ev1s[k].get('value')+ev2s[k].get('value'))/
↪(abs(ev1s[k].get('value'))+abs(ev2s[k].get('value'))),3))

    d = {'index': indexy, 'moves1': moves1, 'evaluation pos1': ev1s,
                 'moves2': moves2, 'evaluation pos2': ev2s, 'epsilons':␣
↪epsilons, 'deltas': deltas, 'MR respected': MR}
    df = pd.DataFrame(data=d)
    print('Done!', end='', flush=True)
    print('\r', end='', flush=True)
    return df
```

[ ]:
```
carlsen_nepo_analysis(30,15)
```

0

For some reasons we are getting only one error, and not 4 as the article got.

[ ]:
```
carlsen_nepo_analysis(30,16)
```

Trying with Stockfish 16, and MR are not violated anymore.

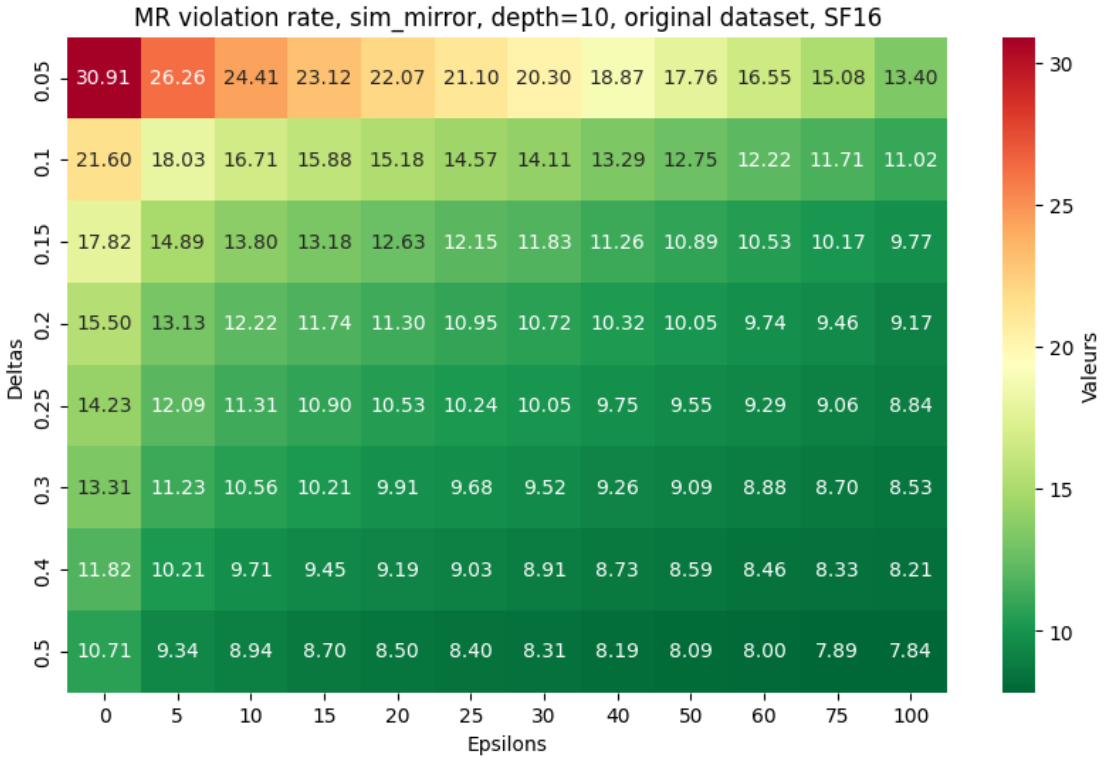
## 0.10 Tests with Stockfish 16

Since the original paper was using Stockfish 15, the previous tests were conducted on this version. The following tests have been conducted with the latest version, Stockfish 16.

### 0.10.1 sim_mirror

**depth = 10, entire dataset (Link V15)**

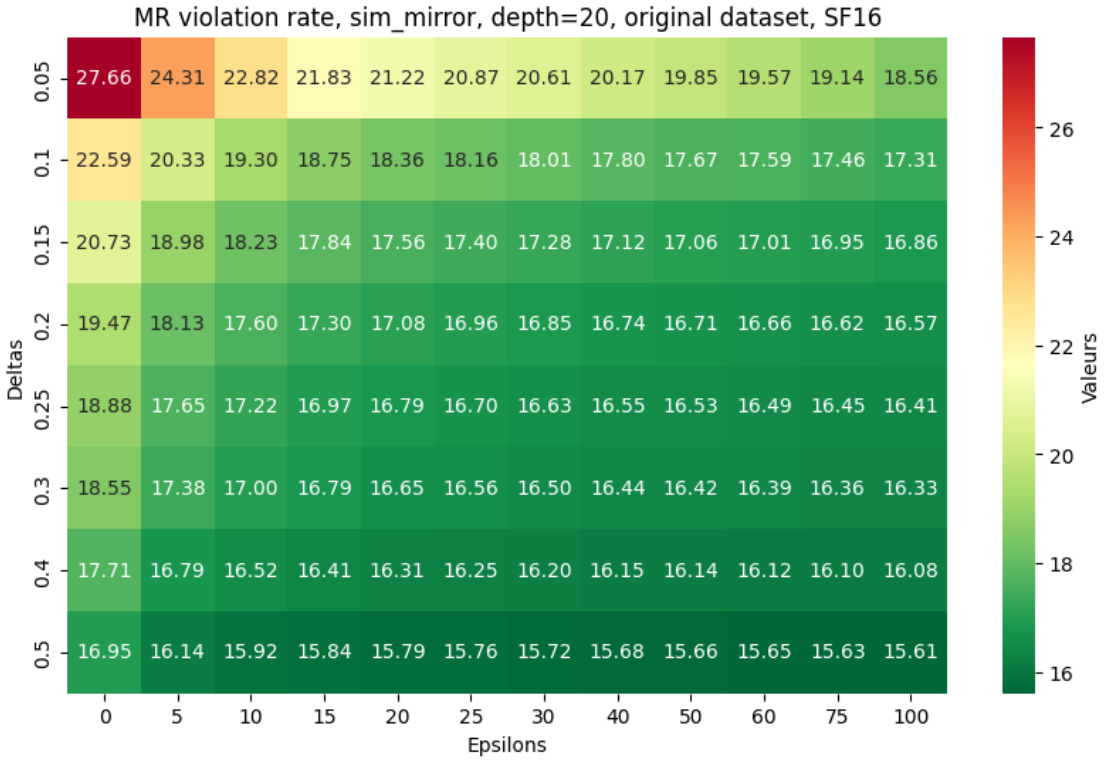
[766]:
```
path = os.path.join('sim_mirror_d=10','evaluations50000_sim_mirror_d_10_v16.
↪pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_mirror_d_10_v16 = pickle.load(file)


tests(evaluations50000_sim_mirror_d_10_v16,0,10, ', original dataset, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 10.48% and 36.15%.

**depth = 20, entire dataset (Link V15)**

[727]:
```
path = os.path.join('sim_mirror_d=20','evaluations50000_sim_mirror_d_20_v16.
↪pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_mirror_d_20_v16 = pickle.load(file)


tests(evaluations50000_sim_mirror_d_20_v16,0,20, ', original dataset, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 19.32% and 36.31%.

Similar behaviour: increasing depth isn't better on the entire dataset.

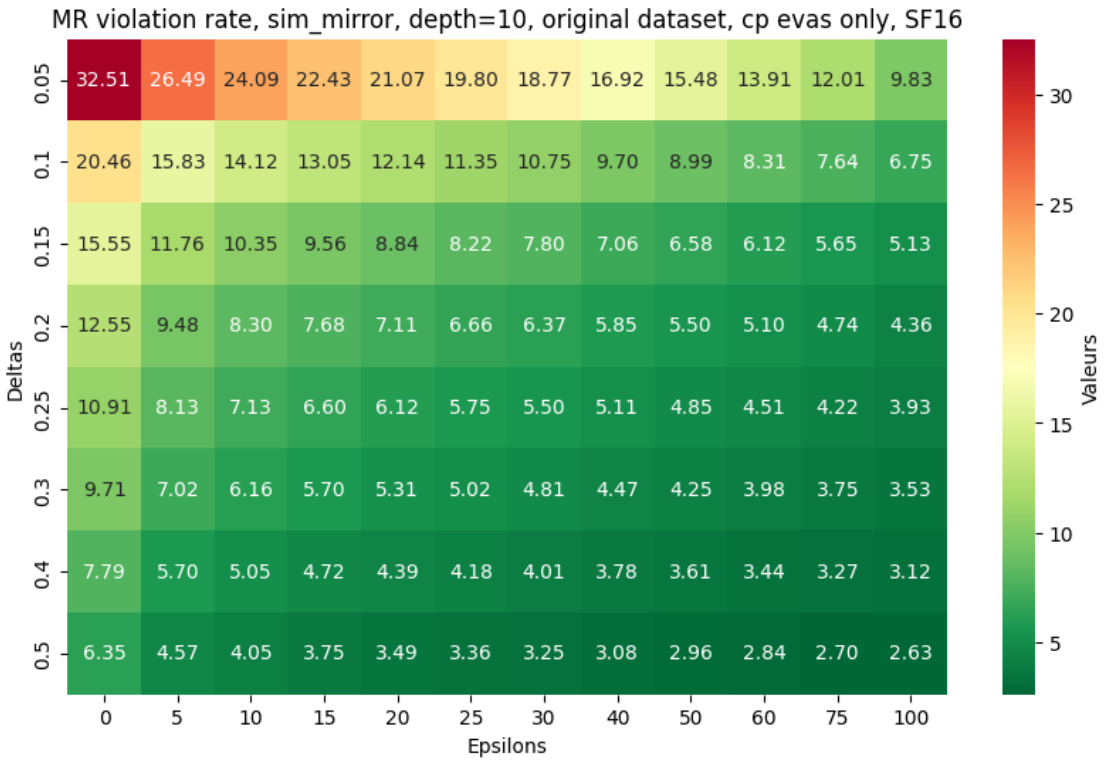
**depth = 10, splitting (Link V15)**

[760]:
```
print("Mates proportion : ",␣
↪len(split_mate_cp(evaluations50000_sim_mirror_d_10_v16)[1])/
↪(len(split_mate_cp(evaluations50000_sim_mirror_d_10_v16)[0])+len(split_mate_cp(evaluations5
```

```
Mates proportion :  0.22773591535548354
```

**Evaluations with a difference in centipawns**

[761]:
```
tests(split_mate_cp(evaluations50000_sim_mirror_d_10_v16)[0],0,10, ', original␣
↪dataset, cp evas only, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 0.93% and 36.74%.

[762]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_sim_mirror_d_10_v16)[1],0,1,1),'%')
```

```
Mates failure rate :  25.492885307731868 %
```

Note : the mates failure rate with Stockfish 15 was ~34.6%.

### depth = 20, splitting (Link V15)

[128]:
```
print("Mates proportion : ",␣
  ↪len(split_mate_cp(evaluations50000_sim_mirror_d_20_v16)[1])/
  ↪(len(split_mate_cp(evaluations50000_sim_mirror_d_20_v16)[0])+len(split_mate_cp(evaluations5
```

```
Mates proportion :  0.47591514630620774
```

### Evaluations with a difference in centipawns

[508]:
```
tests(split_mate_cp(evaluations50000_sim_mirror_d_20_v16)[0],0,20, ', original␣
  ↪dataset, cp evas only, SF16')
```


Note : the failure rate with Stockfish 15 was comprised between 2.01% and 38.67%.

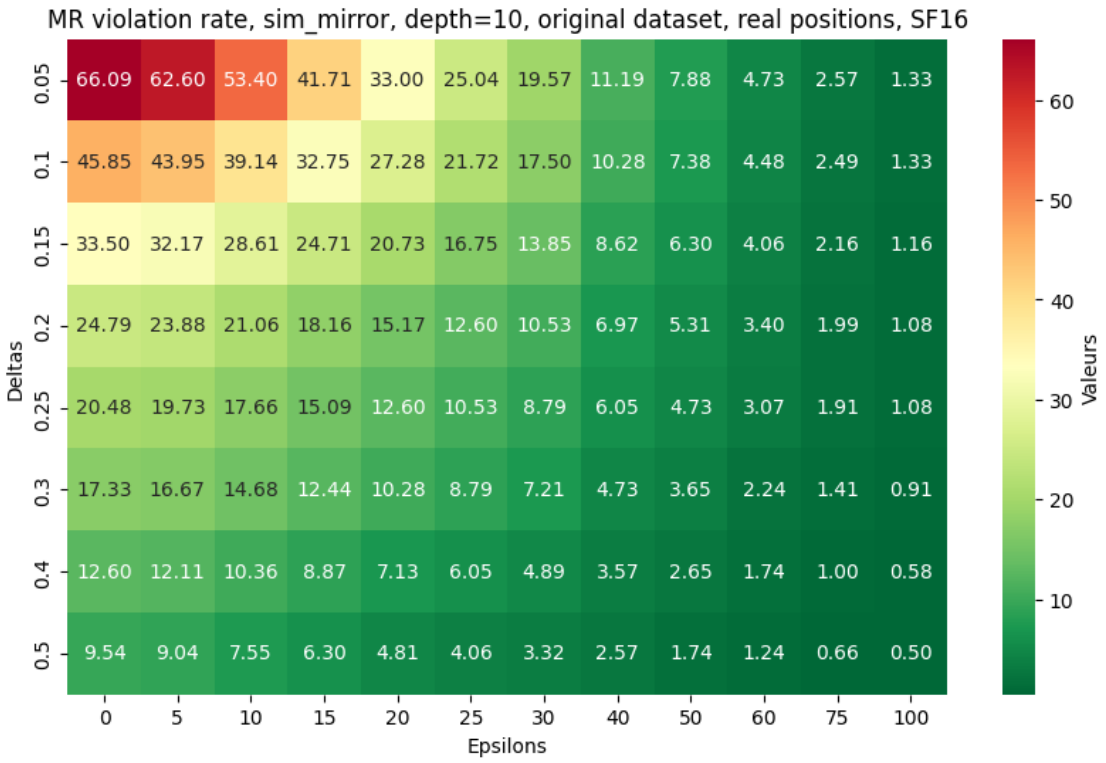
[130]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_sim_mirror_d_20_v16)[1],0,1,1),'%')
```

```
Mates failure rate :  29.89656870792973 %
```

Note : the mates failure rate with Stockfish 15 was ~34.3%.

### depth = 10, real positions (Link V15)

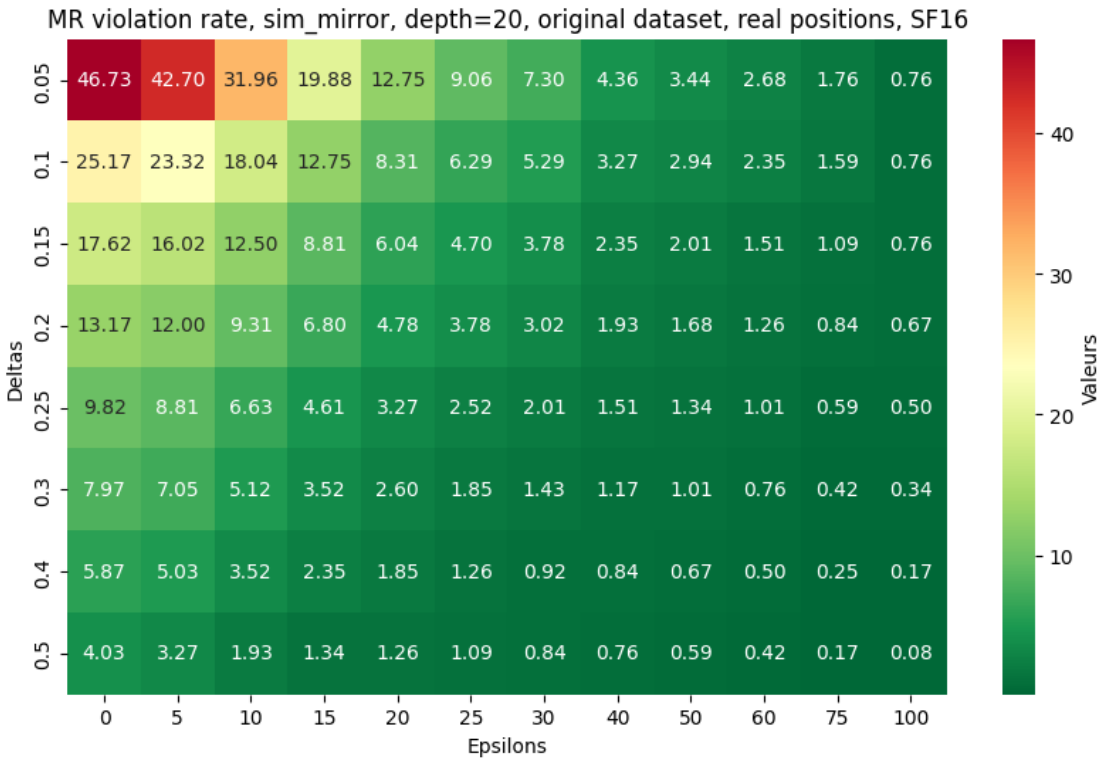
[765]:
```
evaluations50000_sim_mirror_d_10_v16_real =␣
  ↪real_positions(evaluations50000_sim_mirror_d_10_v16[24000:])
evaluations50000_sim_mirror_d_10_v16_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_sim_mirror_d_10_v16_real,0,10, ', original dataset, real␣
  ↪positions, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 1.00% and 66.25%.

**depth = 20, real positions (Link V15)**

[509]:
```
evaluations50000_sim_mirror_d_20_v16_real =␣
↪real_positions(evaluations50000_sim_mirror_d_20_v16[24000:])
evaluations50000_sim_mirror_d_20_v16_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_sim_mirror_d_20_v16_real,0,20, ', original dataset, real␣
↪positions, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 0.25% and 50.67%.

### 0.10.2 sim_axis

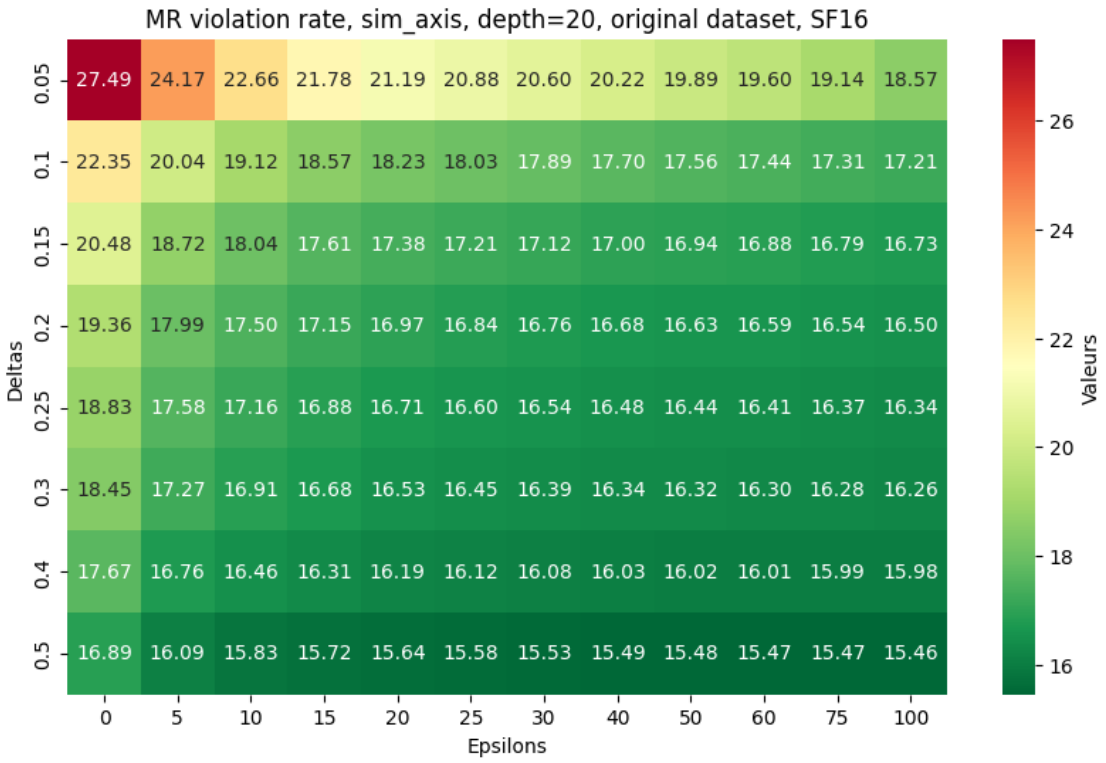
**depth = 10, entire dataset (Link V15)**

[768]:
```
path = os.path.join('sim_axis_d=10','evaluations50000_sim_axis_d_10_v16.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_axis_d_10_v16 = pickle.load(file)


tests(evaluations50000_sim_axis_d_10_v16,1,10, ', original dataset, SF16')
```


Note : the failure rate with Stockfish 15 was comprised between 10.42% and 35.90%.

**depth = 20, entire dataset (Link V15)**

[511]:
```
path = os.path.join('sim_axis_d=20','evaluations50000_sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_axis_d_20_v16 = pickle.load(file)


tests(evaluations50000_sim_axis_d_20_v16,1,20, ', original dataset, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 19.15% and 36.11%.

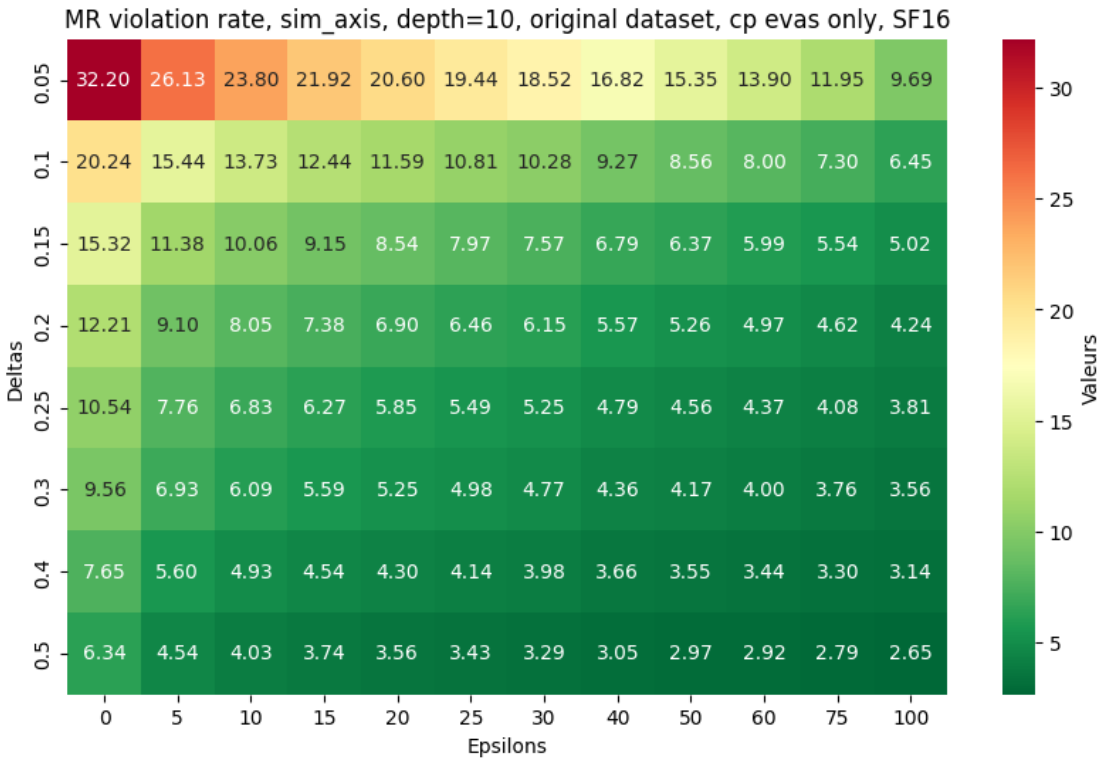
**depth = 10, splitting (Link V15)**

[769]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_sim_axis_d_10_v16)[1])/
 ↪(len(split_mate_cp(evaluations50000_sim_axis_d_10_v16)[0])+len(split_mate_cp(evaluations500
```

```
Mates proportion :  0.22955350539141267
```

**Evaluations with a difference in centipawns**

[770]:
```
tests(split_mate_cp(evaluations50000_sim_axis_d_10_v16)[0],1,10, ', original␣
 ↪dataset, cp evas only, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 0.96% and 36.54%.

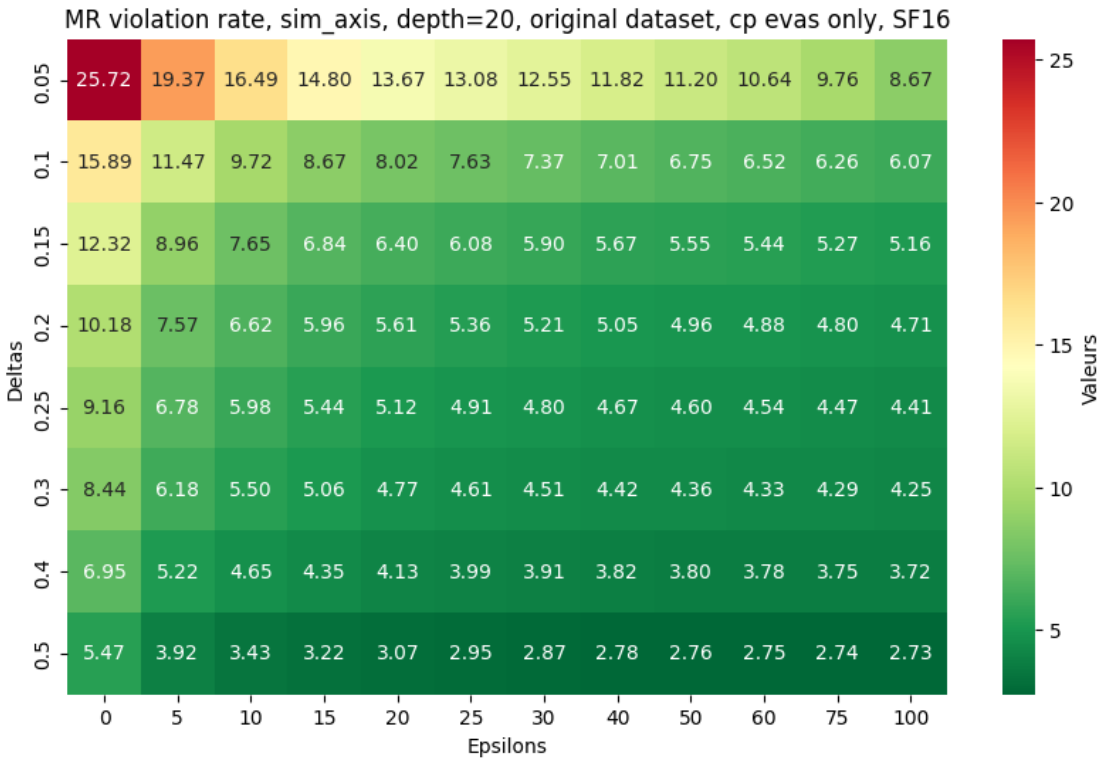
**depth = 20, splitting (Link V15)**

[133]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_sim_axis_d_20_v16)[1])/
 ↪(len(split_mate_cp(evaluations50000_sim_axis_d_20_v16)[0])+len(split_mate_cp(evaluations500
```

```
Mates proportion :  0.4768823277373116
```

**Evaluations with a difference in centipawns**

[512]:
```
tests(split_mate_cp(evaluations50000_sim_axis_d_20_v16)[0],1,20, ', original␣
 ↪dataset, cp evas only, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 2.05% and 38.59%.

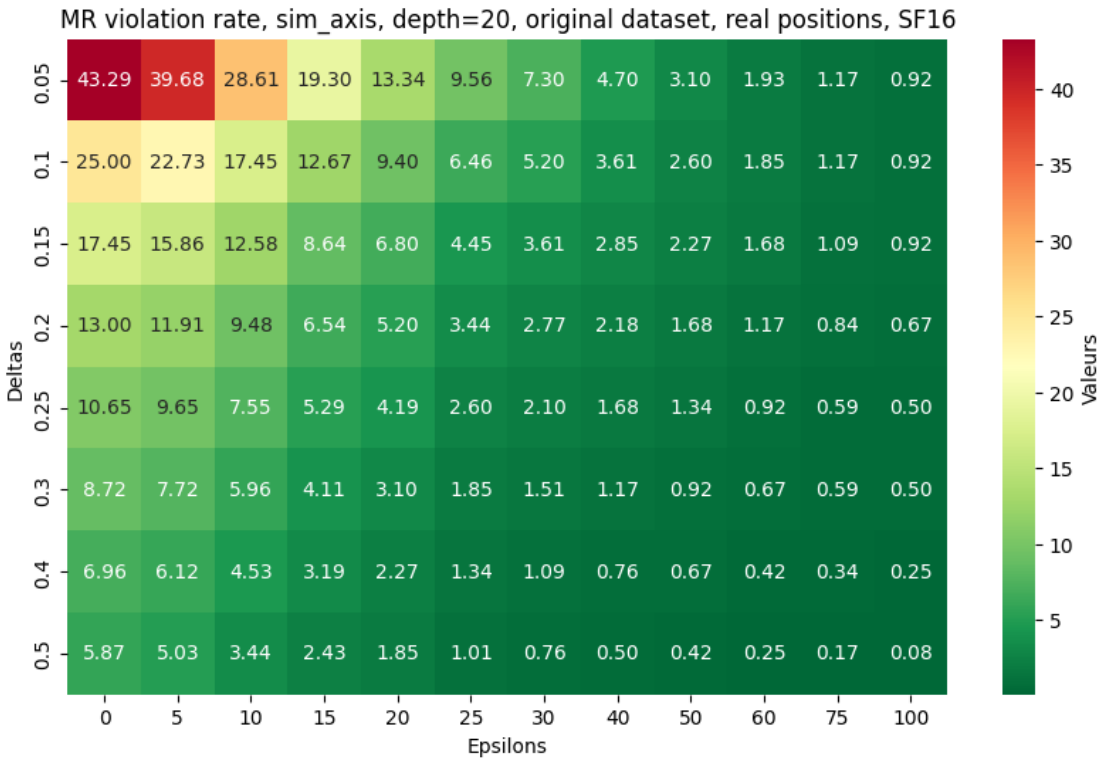
[135]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_sim_axis_d_20_v16)[1],1,1,1),'%')
```

```
Mates failure rate :  29.42906150453321 %
```

Note : the mates failure rate with Stockfish 15 was ~34.0%.

**depth = 20, real positions (Link V15)**

[513]:
```
evaluations50000_sim_axis_d_20_v16_real =␣
  ↪real_positions(evaluations50000_sim_axis_d_20_v16[24000:])
evaluations50000_sim_axis_d_20_v16_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_sim_axis_d_20_v16_real,1,20, ', original dataset, real␣
  ↪positions, SF16')
```

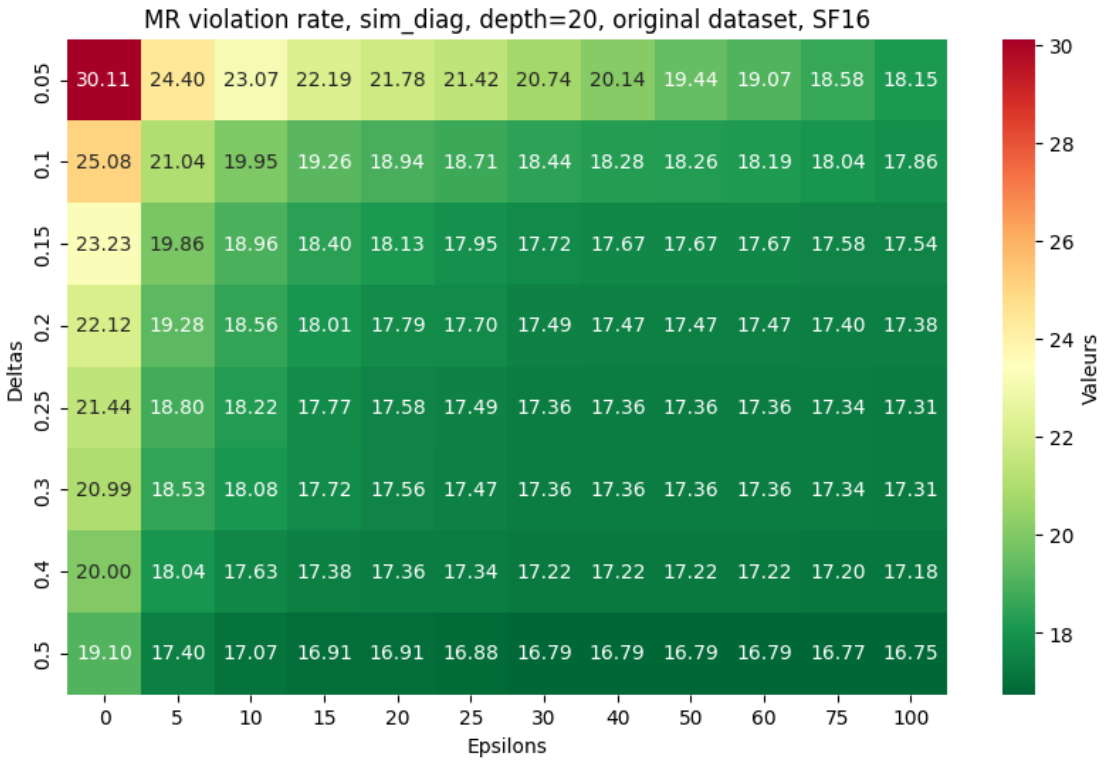



Note : the failure rate with Stockfish 15 was comprised between 0.25% and 50.04%.

### 0.10.3 sim_diag

**depth = 20, entire dataset (Link V15)**

[514]:
```
path = os.path.join('sim_diag_d=20','evaluations50000_sim_diag_d_20_v16.pkl')
with open(path, 'rb') as file:
    evaluations50000_sim_diag_d_20_v16 = pickle.load(file)

tests(evaluations50000_sim_diag_d_20_v16,2,20, ', original dataset, SF16')
```



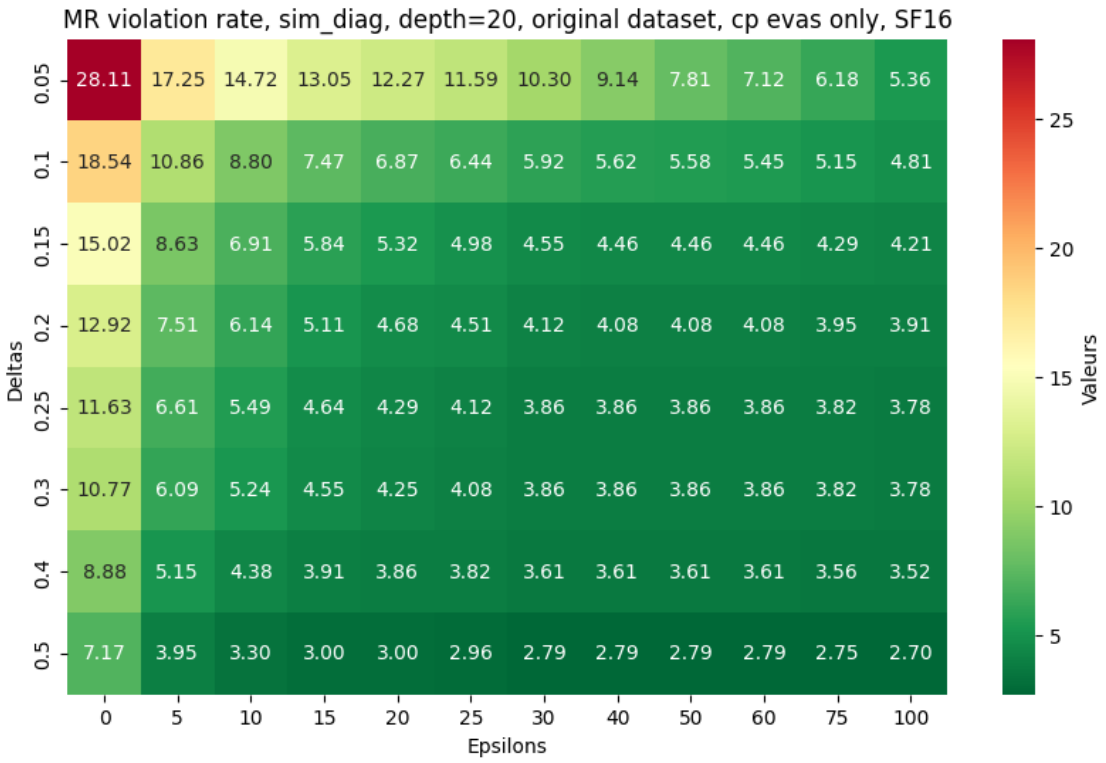

Note : the failure rate with Stockfish 15 was comprised between 22.28% and 41.36%. #### depth = 20, splitting (Link V15)

[138]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_sim_diag_d_20_v16)[1])/
 ↪(len(split_mate_cp(evaluations50000_sim_diag_d_20_v16)[0])+len(split_mate_cp(evaluations500
```

```
Mates proportion :  0.47404063205417607
```

**Evaluations with a difference in centipawns**

[515]:
```
tests(split_mate_cp(evaluations50000_sim_diag_d_20_v16)[0],2,20, ', original␣
 ↪dataset, cp evas only, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 2.41% and 48.55%.

[140]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_sim_diag_d_20_v16)[1],2,1,1),'%')
```

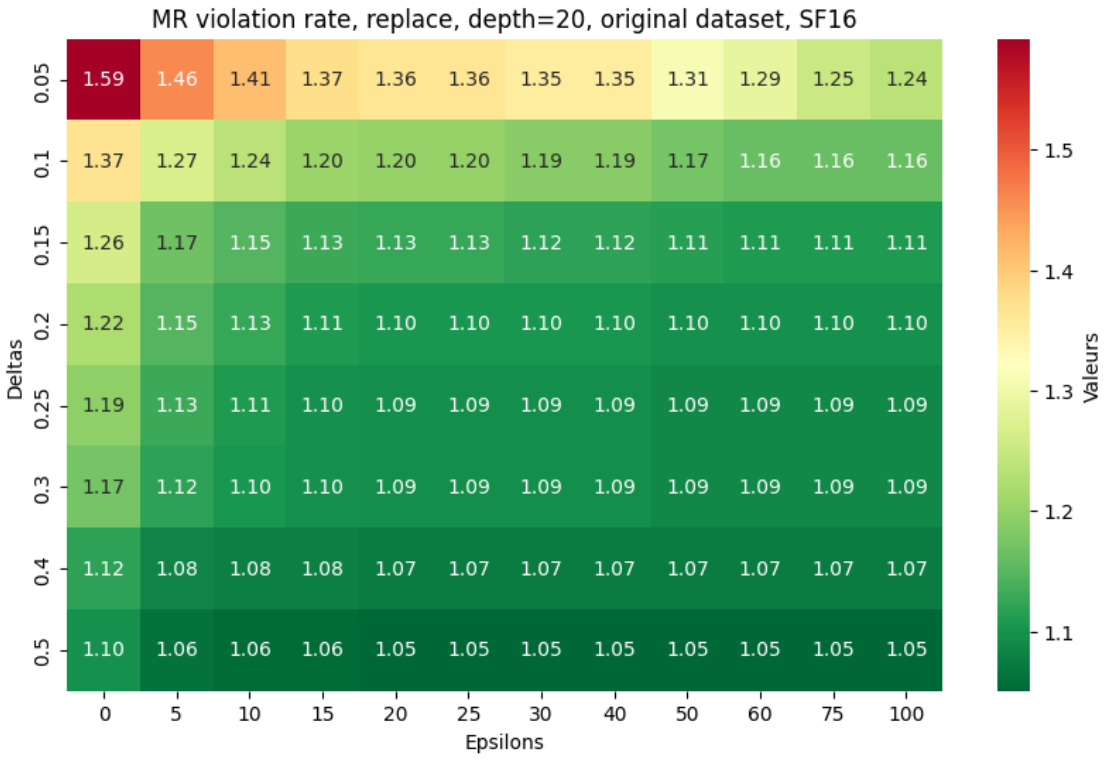
```
Mates failure rate :  32.33333333333334 %
```

Note : the mates failure rate with Stockfish 15 was ~38.5%.

### 0.10.4 replace

**depth = 20, entire dataset (Link V15)**

[516]:
```
path = os.path.join('replace_d=20','evaluations50000_replace_d_20_v16.pkl')
with open(path, 'rb') as file:
    evaluations50000_replace_d_20_v16 = pickle.load(file)


tests(evaluations50000_replace_d_20_v16,3,20, ', original dataset, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 1.29% and 2.06%.

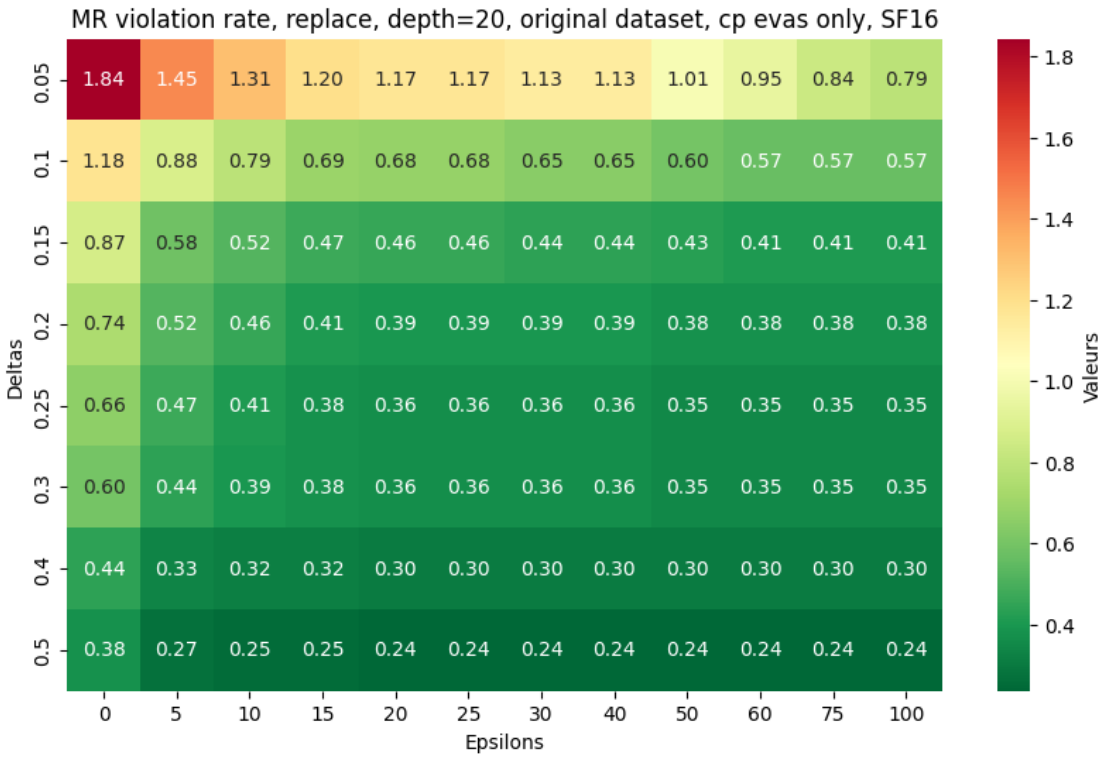
**depth = 20, splitting (Link V15)**

[142]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_replace_d_20_v16)[1])/
 ↪(len(split_mate_cp(evaluations50000_replace_d_20_v16)[0])+len(split_mate_cp(evaluations5000
```

```
Mates proportion :  0.663164039696439
```

**Evaluations with a difference in centipawns**

[517]:
```
tests(split_mate_cp(evaluations50000_replace_d_20_v16)[0],3,20, ', original␣
 ↪dataset, cp evas only, SF16')
```



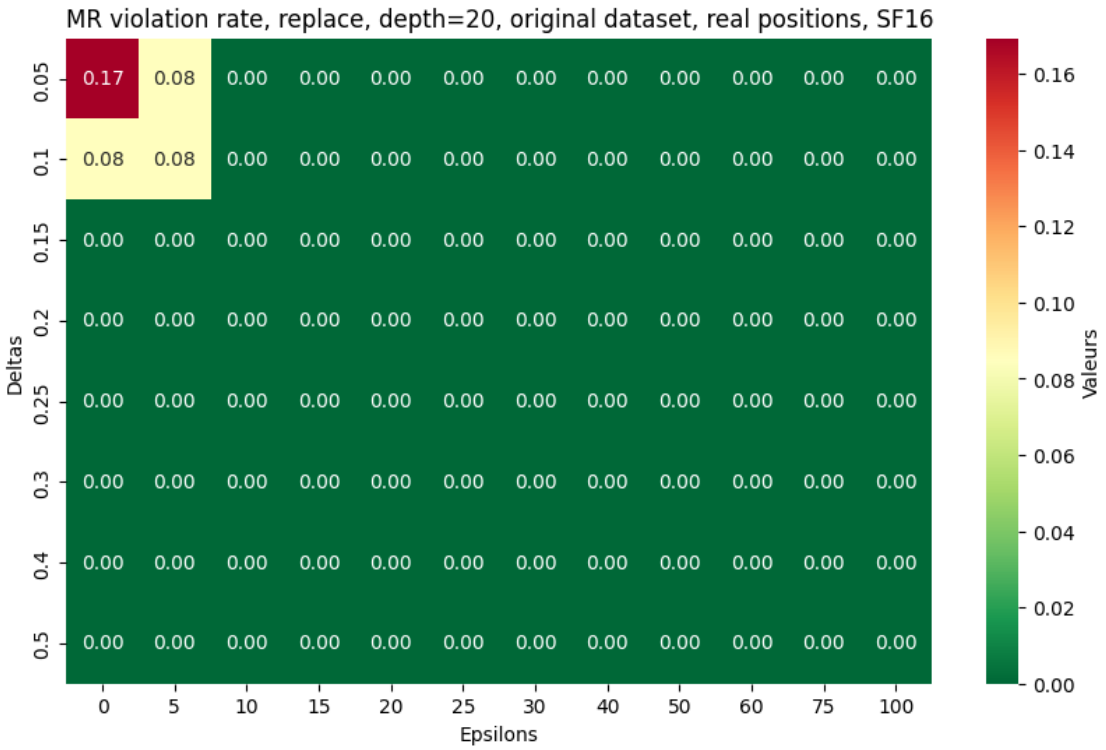

Note : the failure rate with Stockfish 15 was comprised between 0.22% and 2.86%.

[144]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_replace_d_20_v16)[1],3,1,1),'%')
```

```
Mates failure rate :  1.464468629961587 %
```

### depth = 20, real positions (Link V15)

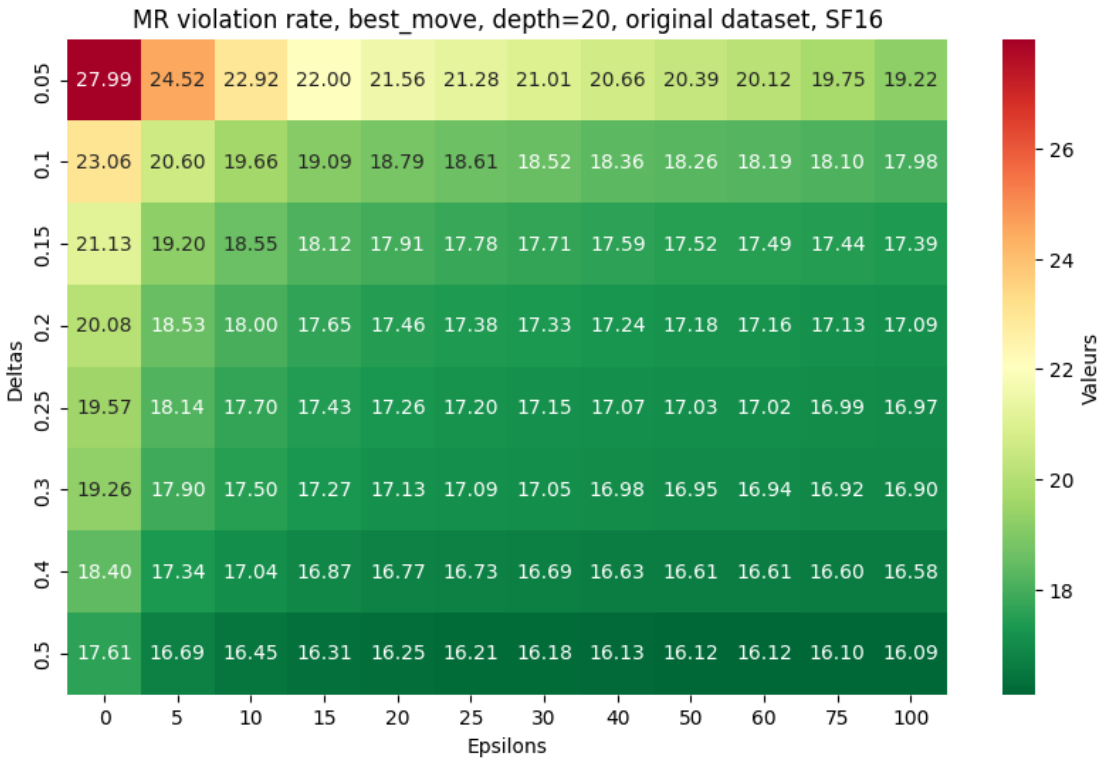
[518]:
```
evaluations50000_replace_d_20_v16_real =␣
  ↪real_positions(evaluations50000_replace_d_20_v16[17000:])
evaluations50000_replace_d_20_v16_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_replace_d_20_v16_real,3,20, ', original dataset, real␣
  ↪positions, SF16')
```




### 0.10.5 best_move

**depth = 20, entire dataset (Link V15)**

[519]:
```
path = os.path.join('best_move_d=20','evaluations50000_best_move_d_20_v16.pkl')
with open(path, 'rb') as file:
    evaluations50000_best_move_d_20_v16 = pickle.load(file)


tests(evaluations50000_best_move_d_20_v16,4,20, ', original dataset, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 19.68% and 36.68%.

**depth = 20, splitting (Link V15)**

[147]:
```
print("Mates proportion : ",␣
 ↪len(split_mate_cp(evaluations50000_best_move_d_20_v16)[1])/
 ↪(len(split_mate_cp(evaluations50000_best_move_d_20_v16)[0])+len(split_mate_cp(evaluations50
```

```
Mates proportion :  0.4718529330545584
```

**Evaluations with a difference in centipawns**

[520]:
```
tests(split_mate_cp(evaluations50000_best_move_d_20_v16)[0],4,20, ', original␣
 ↪dataset, cp evas only, SF16')
```

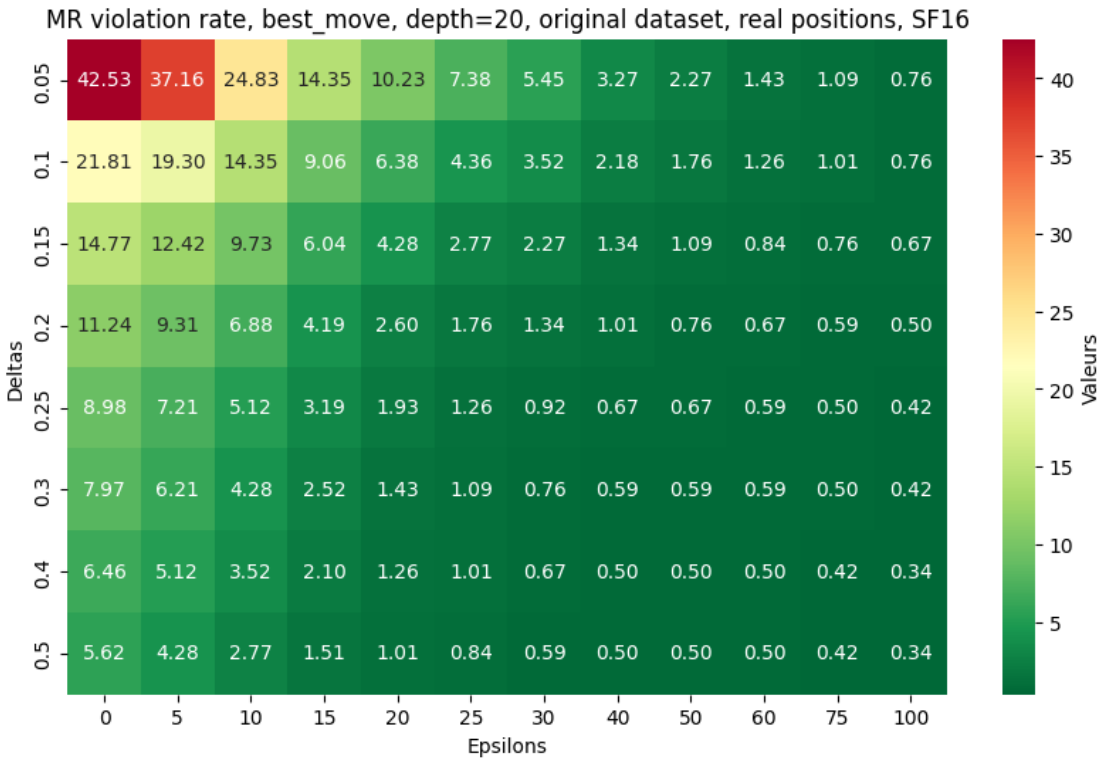

Note : the failure rate with Stockfish 15 was comprised between 5.81% and 41.58%.

[149]:
```
print('Mates failure rate :␣
  ↪',100-MR(split_mate_cp(evaluations50000_best_move_d_20_v16)[1],4,1,1),'%')
```

```
Mates failure rate :  28.124738734219548 %
```

### depth = 20, real positions (Link V15)

[521]:
```
evaluations50000_best_move_d_20_v16_real =␣
  ↪real_positions(evaluations50000_best_move_d_20_v16[22000:])
evaluations50000_best_move_d_20_v16_real.reset_index(drop=True, inplace=True)
tests(evaluations50000_best_move_d_20_v16_real,4,20, ', original dataset, real␣
  ↪positions, SF16')
```




Note : the failure rate with Stockfish 15 was comprised between 0.34% and 48.95%.

### 0.10.6 Differences in evaluations between SF15 and SF16

We'll also show grids with using MR_equi to check the variations between SF15 and SF16 on the both original and mutated positions, by merging two dataframes and keeping only the columns about the positions we want, using the functions below.

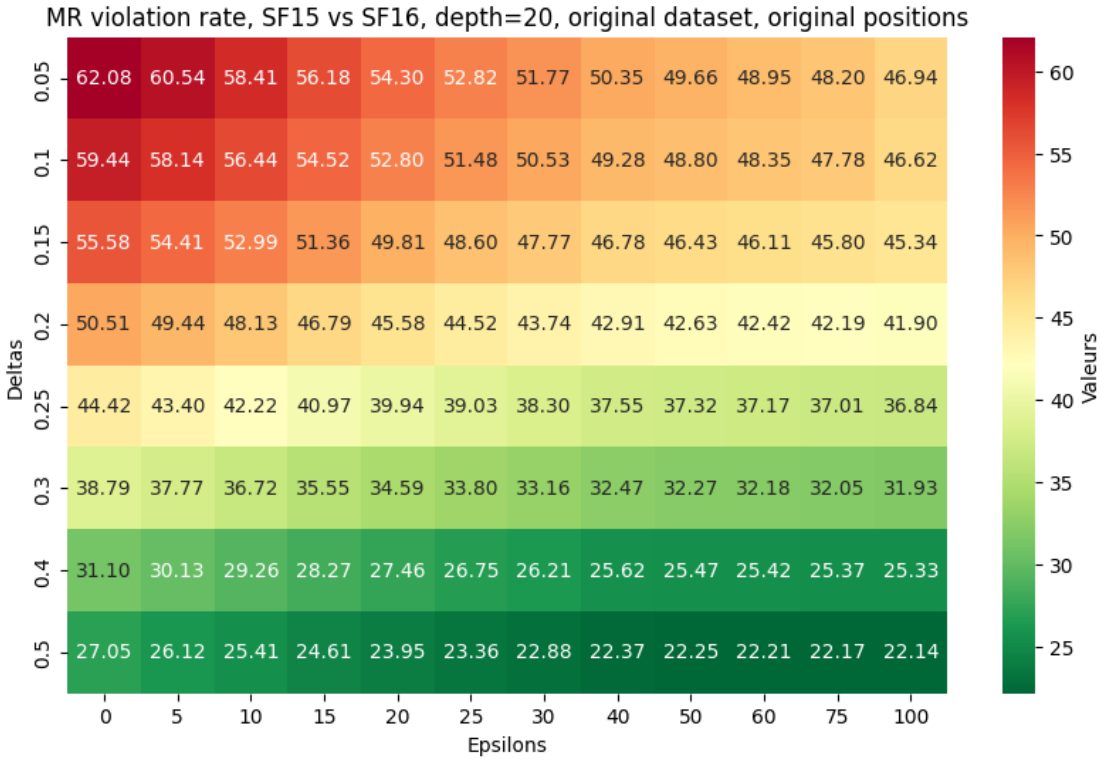
[433]:
```
def merge(evas1,evas2):
    evas1 = evas1[['pos1','evaluation pos1']]
    evas2 = evas2[['pos1','evaluation pos1']]

    evas2 = evas2.rename(columns={'evaluation pos1': 'evaluation pos2'})

    evas1.reset_index(drop=True, inplace=True)
    evas2.reset_index(drop=True, inplace=True)

    merged_dataset = pd.merge(evas1, evas2, on='pos1', how='inner')
    merged_dataset.insert(0, 'index', range(1, len(merged_dataset) + 1))


    return merged_dataset
```

```
def merge2(evas1,evas2):
    evas1 = evas1[['pos2','evaluation pos2']]
    evas2 = evas2[['pos2','evaluation pos2']]

    evas1 = evas1.rename(columns={'pos2': 'pos1'})
    evas2 = evas2.rename(columns={'pos2': 'pos1'})

    evas1 = evas1.rename(columns={'evaluation pos2': 'evaluation pos1'})

    evas1.reset_index(drop=True, inplace=True)
    evas2.reset_index(drop=True, inplace=True)

    merged_dataset = pd.merge(evas1, evas2, on='pos1', how='inner')
    merged_dataset.insert(0, 'index', range(1, len(merged_dataset) + 1))


    return merged_dataset
```

### Entire dataset

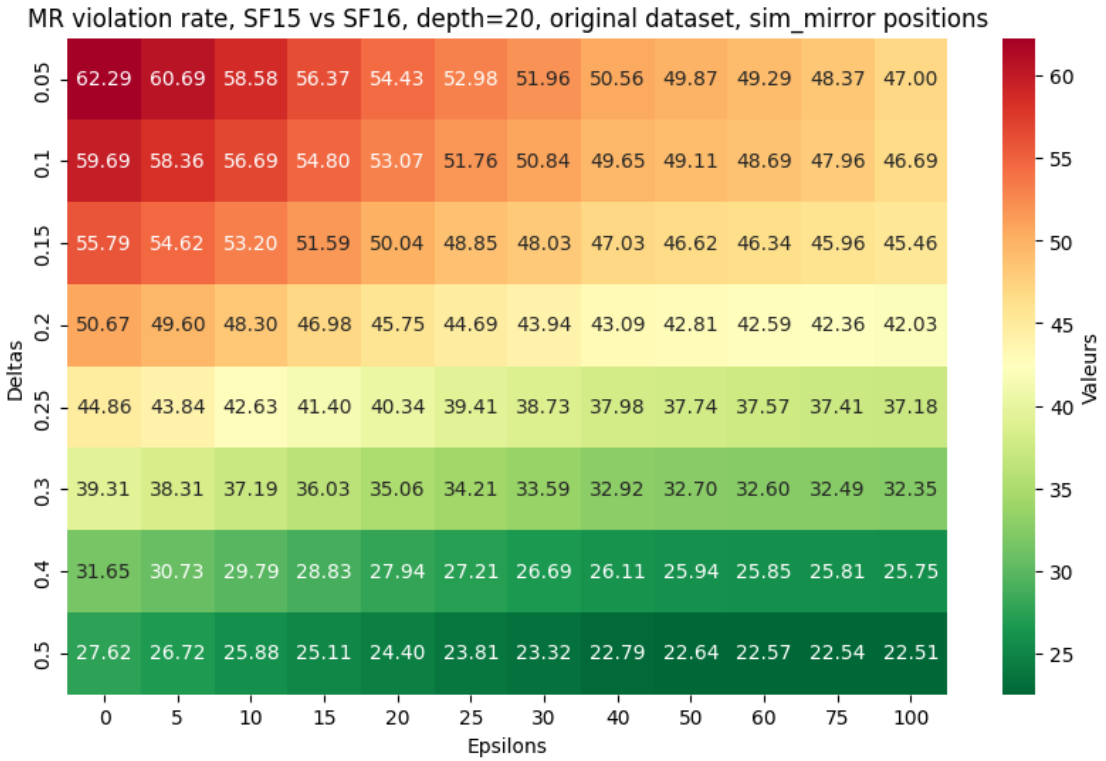
### Original Positions

[523]:
```
tests(merge(evaluations50000_sim_mirror_d_20_v16,evaluations50000_sim_mirror_d_20),5,20,␣
  ↪', original dataset, original positions')
```



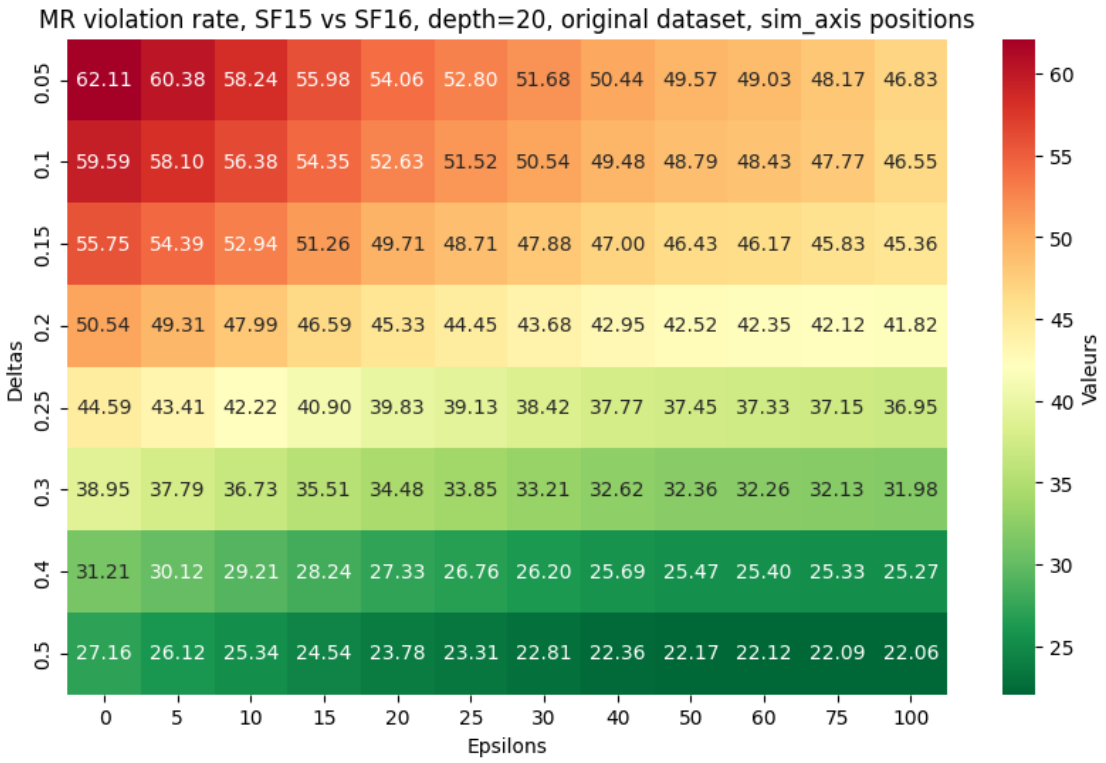
**sim_mirror**

[524]:
```
tests(merge2(evaluations50000_sim_mirror_d_20_v16,evaluations50000_sim_mirror_d_20),5,20,␣
↪', original dataset, sim_mirror positions')
```




**sim_axis**

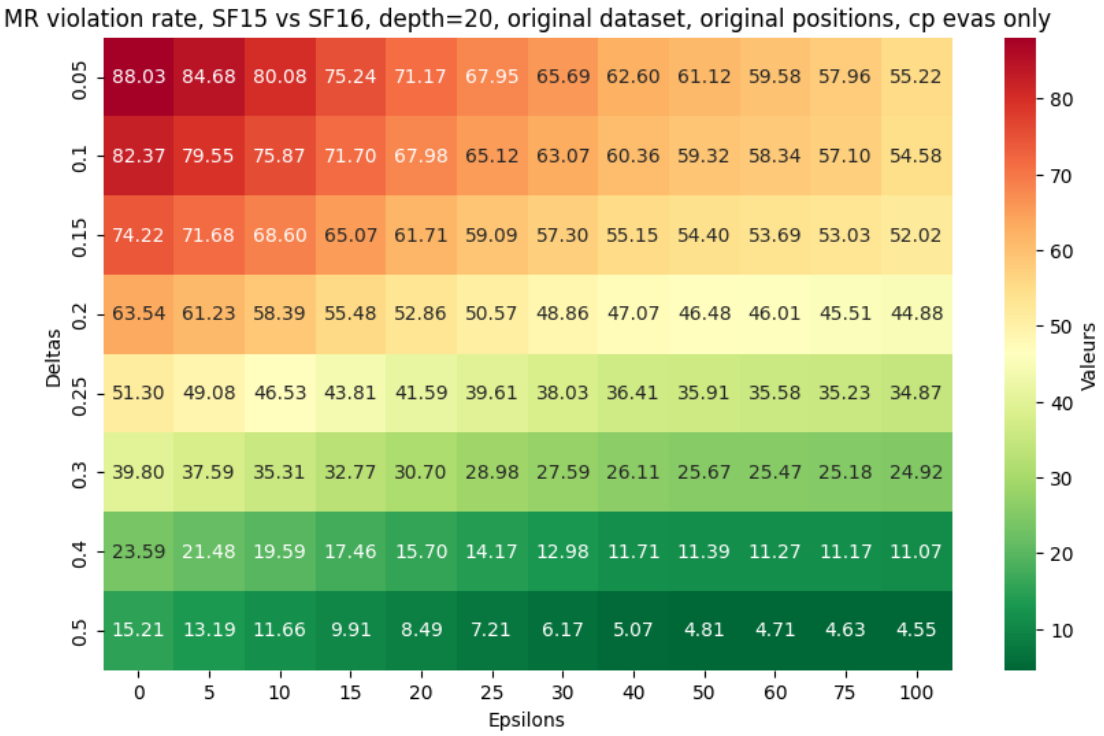
[525]:
```
tests(merge2(evaluations50000_sim_axis_d_20_v16,evaluations50000_sim_axis_d_20),5,20,␣
↪', original dataset, sim_axis positions')
```




**Splitting, positions with evaluations in centipawns only**

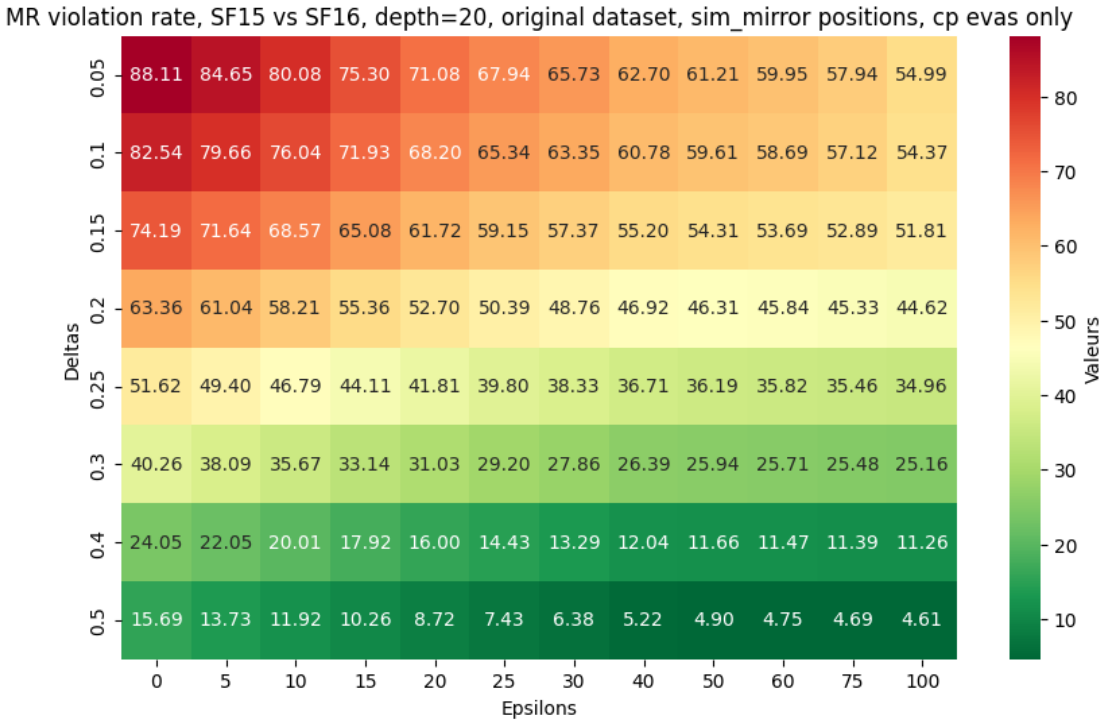
**Original Positions**

[529]:
```
tests(merge(split_mate_cp(evaluations50000_sim_mirror_d_20_v16)[0],split_mate_cp(evaluations50
  ↪', original dataset, original positions, cp evas only')
```



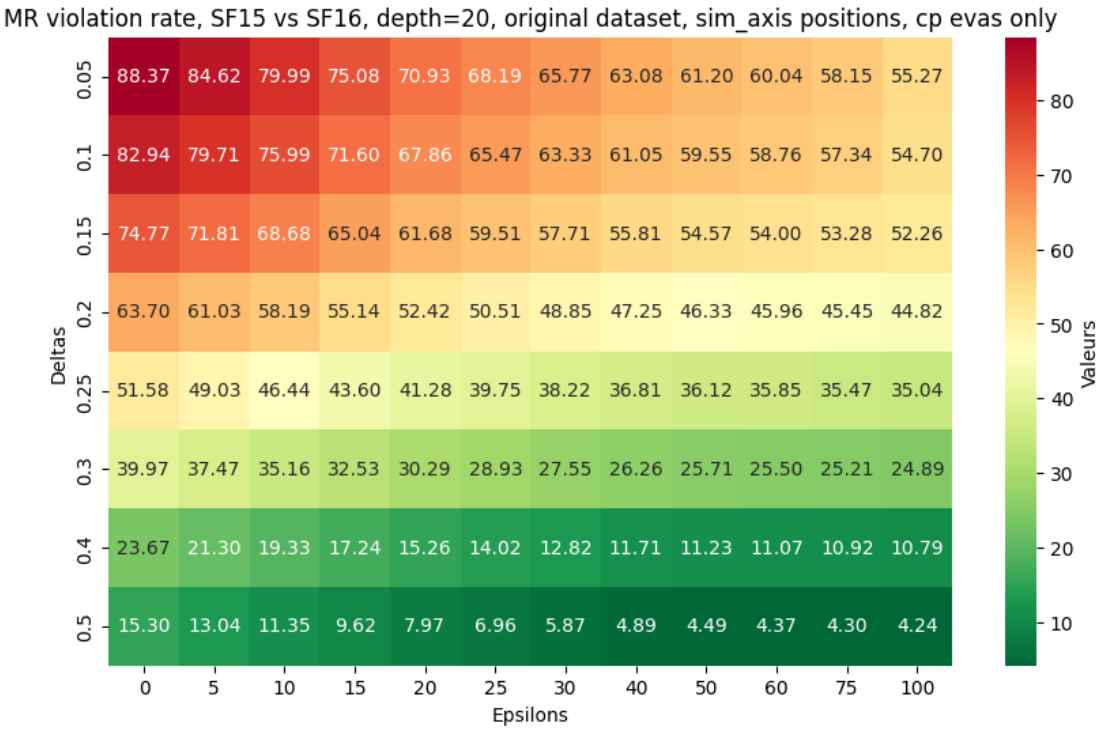

**sim_mirror**

[530]:
```
tests(merge2(split_mate_cp(evaluations50000_sim_mirror_d_20_v16)[0],split_mate_cp(evaluations5
 ↪', original dataset, sim_mirror positions, cp evas only')
```




**sim_axis**

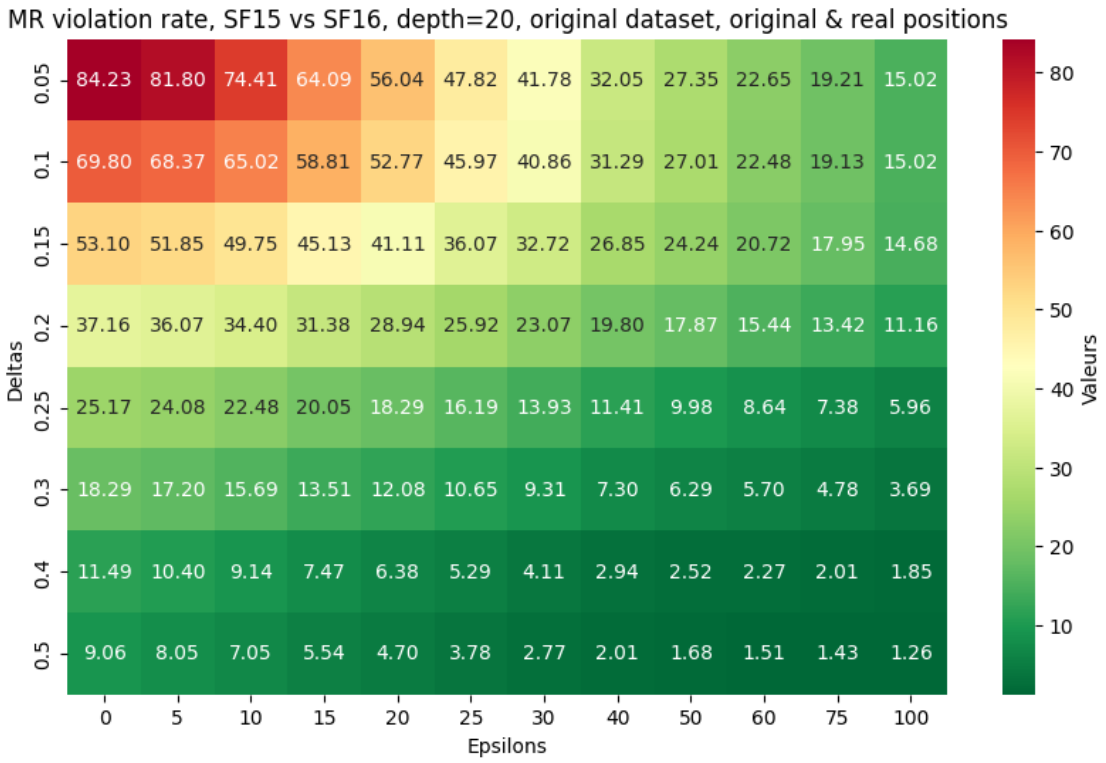
[531]:
```
tests(merge2(split_mate_cp(evaluations50000_sim_axis_d_20_v16)[0],split_mate_cp(evaluations500
  ↪', original dataset, sim_axis positions, cp evas only')
```




### Real positions

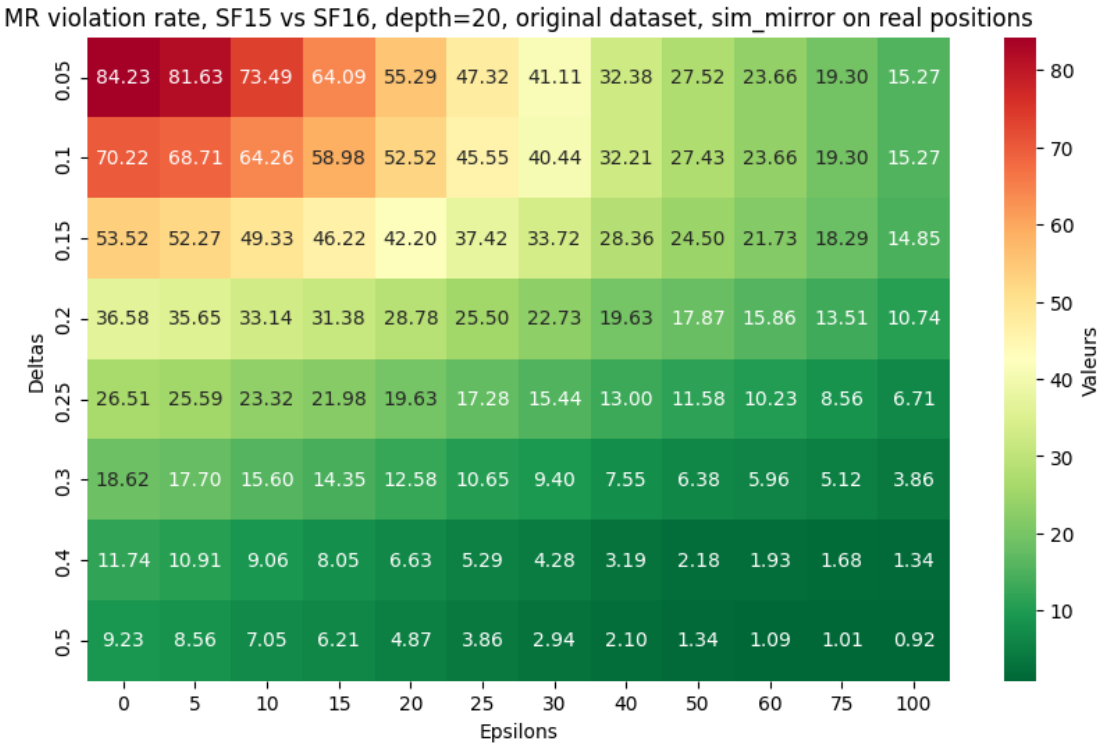
### Original Positions

[533]:
```
tests(merge(evaluations50000_sim_mirror_d_20_v16_real,evaluations50000_sim_mirror_d_20_real),5
  ↪', original dataset, original & real positions')
```



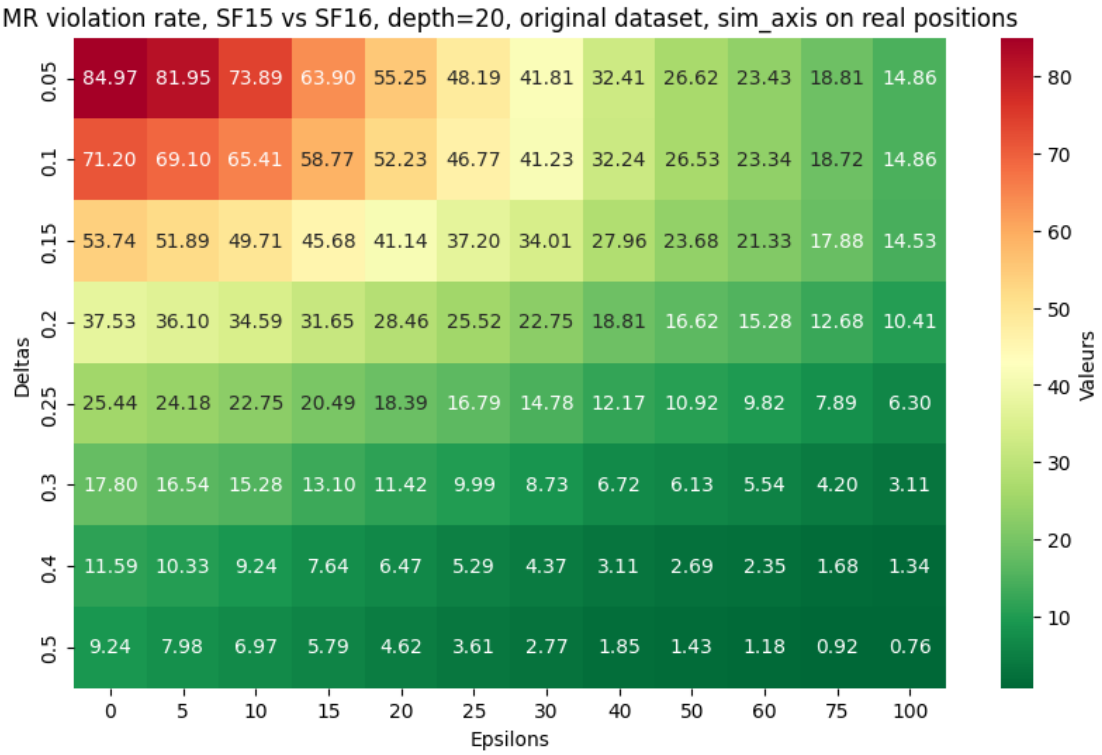

**sim_mirror**

[534]:
```
tests(merge2(evaluations50000_sim_mirror_d_20_v16_real,evaluations50000_sim_mirror_d_20_real),
  ↪', original dataset, sim_mirror on real positions')
```




**sim_axis**

[535]:
```
tests(merge2(evaluations50000_sim_axis_d_20_v16_real,evaluations50000_sim_axis_d_20_real),5,20
  ↪', original dataset, sim_axis on real positions')
```




### 0.10.7 Conclusions with Stockfish 16

This newer version shows slightly better results.

## 0.11 Tests with positions from lichess, Stockfish 15

We took games from the lichess database, and picked position at move 10, 20, 30 and 40. We then split the positions by elo, and also added Carlsen's games. We are using Stockfish 15 there. Moreover, we'll also show grids for positions where castling isn't possible anymore ; the original paper decided to remove the ability to castle on every positions, but if we does that on real positions, even if they still look real, some may actually not be anymore.

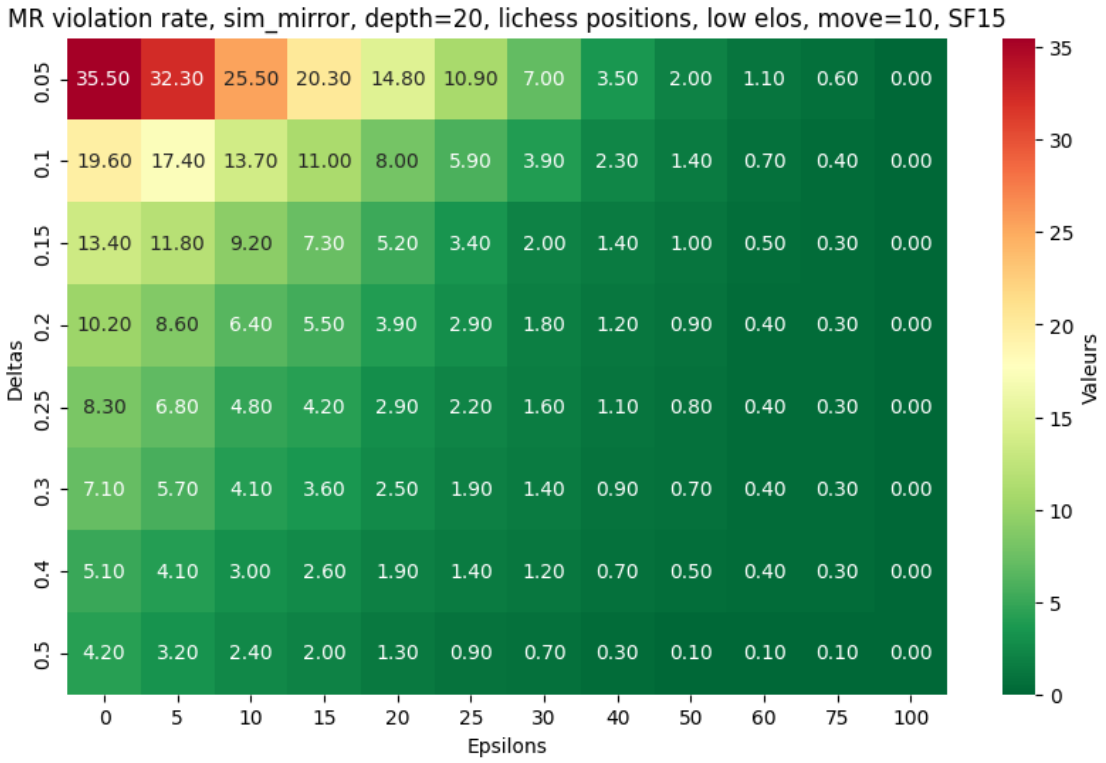
### 0.11.1 sim_mirror

**Openings (move=10)**

**Lichess positions - 1000 to 1500 elo rating**

[538]:
```
path = os.path.join('reals','ev_lichess1000-1500-10sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ', lichess positions, low elos, move=10, SF15')
```

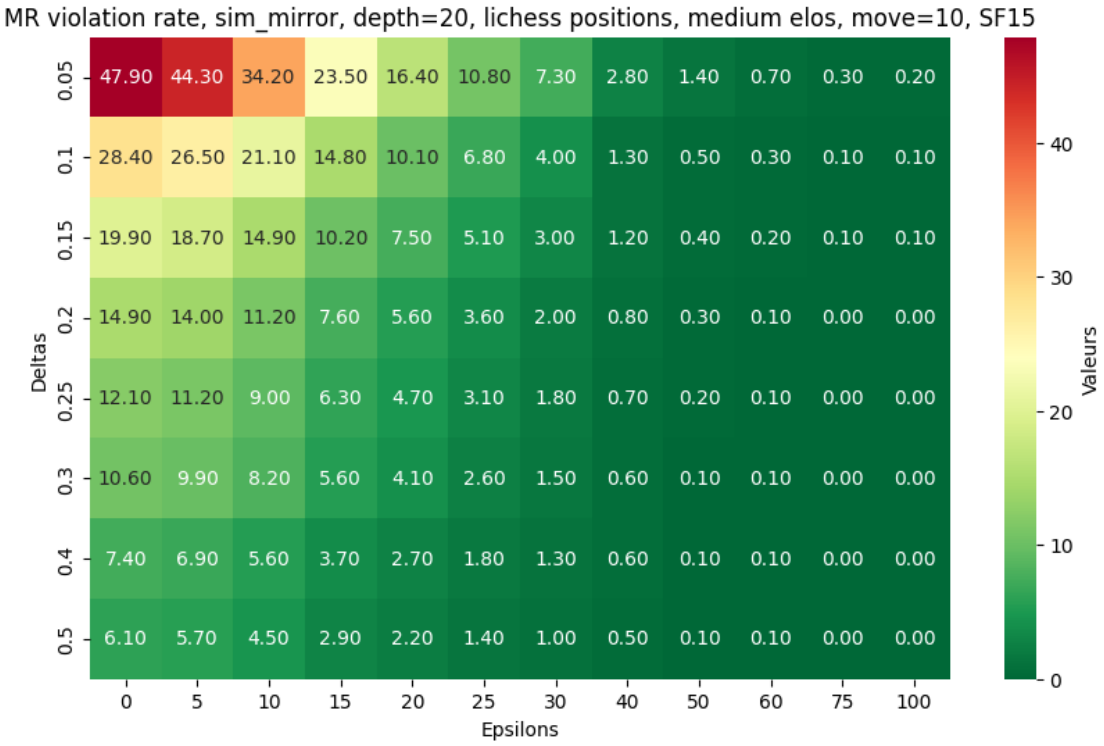
```
move = 10
```




**Lichess positions - 1500 to 2000 elo rating**

[539]:
```
path = os.path.join('reals','ev_lichess1500-2000-10sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ', lichess positions, medium elos, move=10, SF15')
```

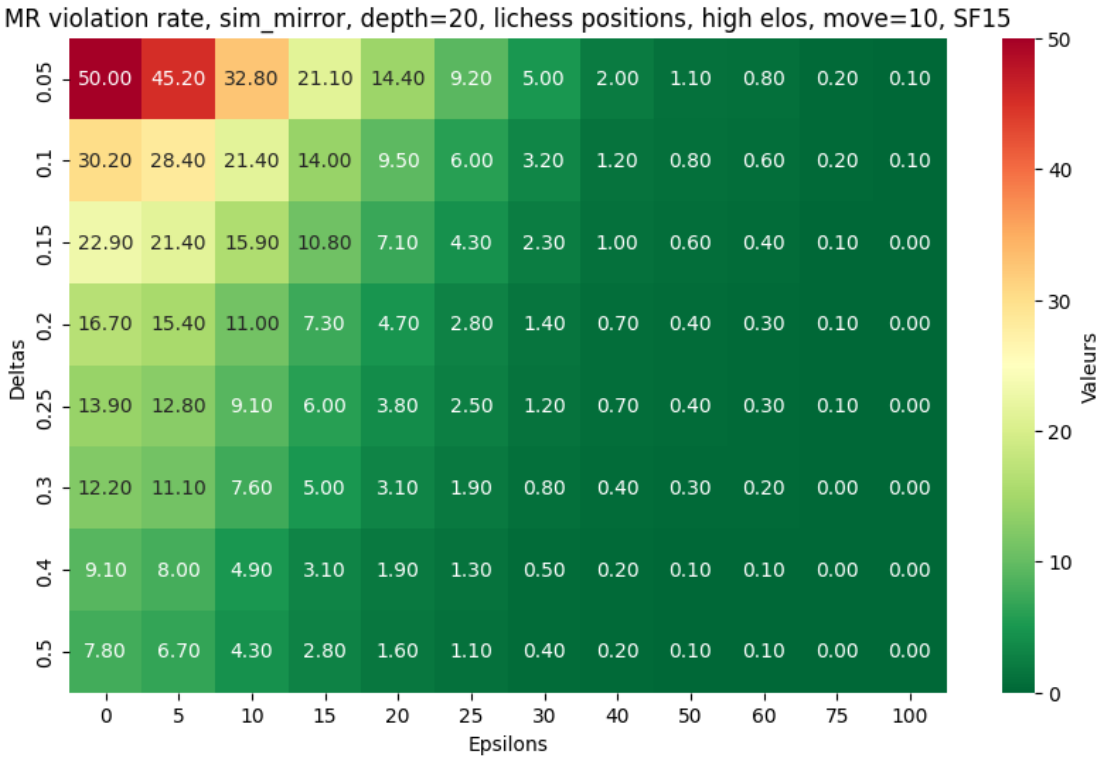
```
move = 10
```




**Lichess positions - 2000 to 2500 elo rating**

[540]:
```
path = os.path.join('reals','ev_lichess2000-2500-10sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ', lichess positions, high elos, move=10, SF15')
```

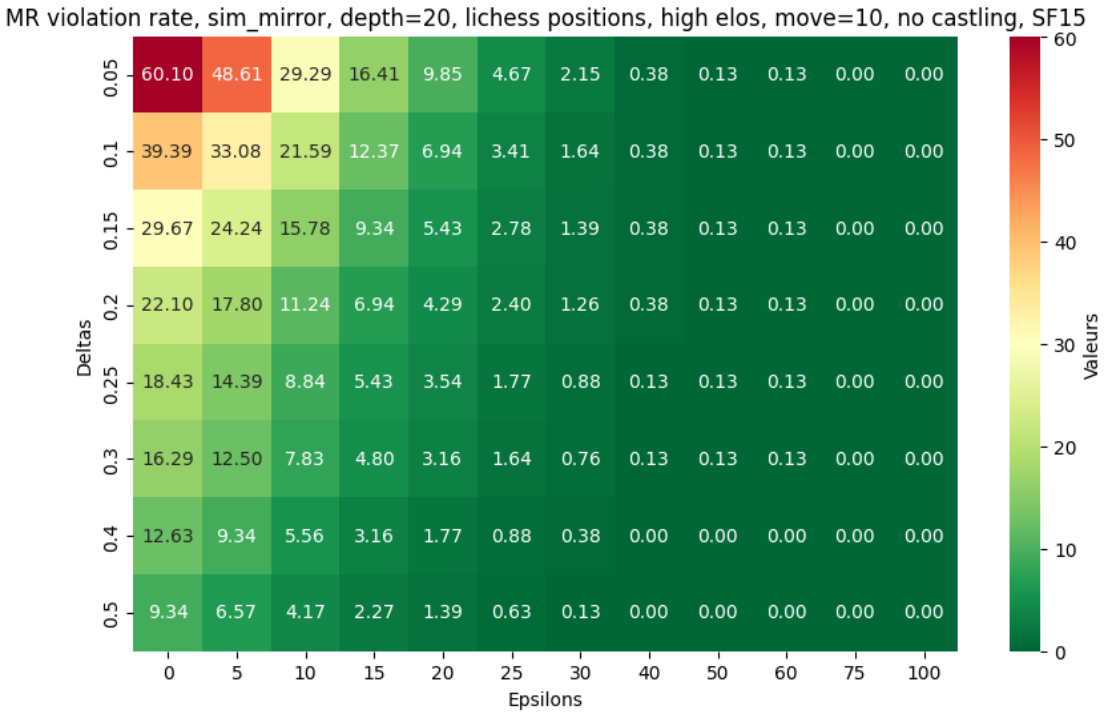
```
move = 10
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[541]:
```
path = os.path.join('reals','ev_lichess2000-2500-10_nocastlingsim_mirror_d_20.
  ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ', lichess positions, high elos, move=10, no castling, SF15')
```

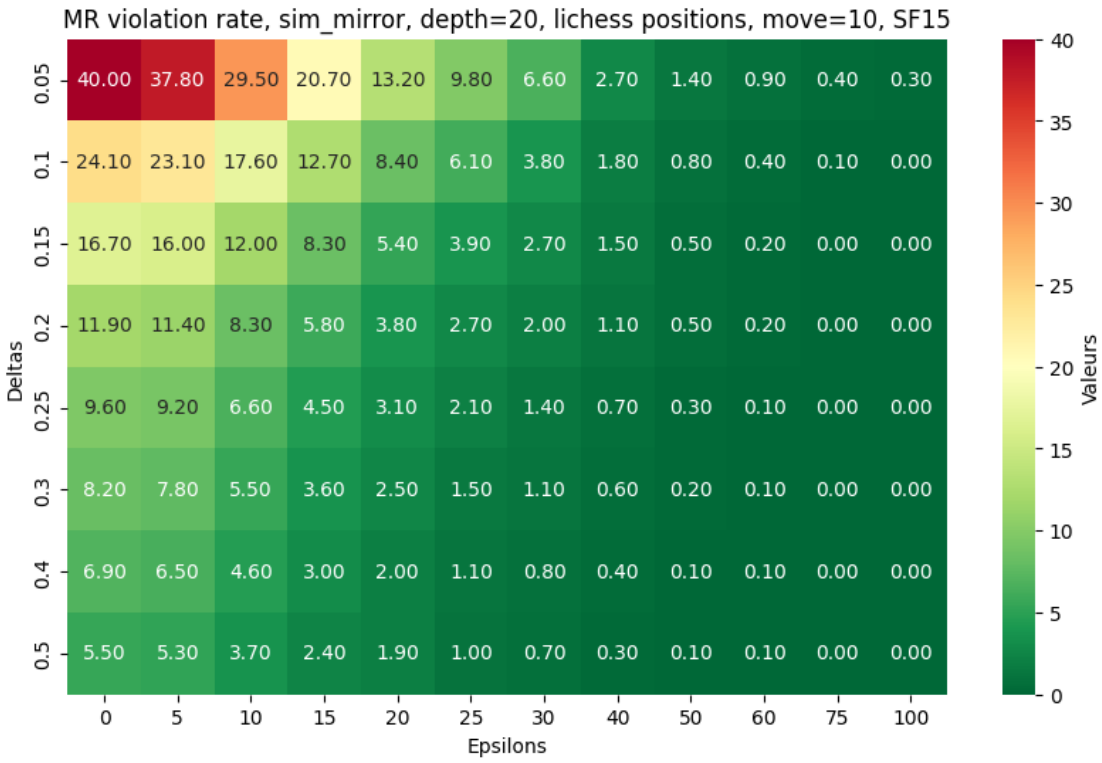
```
move = 10
```




**Lichess positions - All elos**

[542]:
```
path = os.path.join('reals','ev_lichessAllElos-10sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ', lichess positions, move=10, SF15')
```

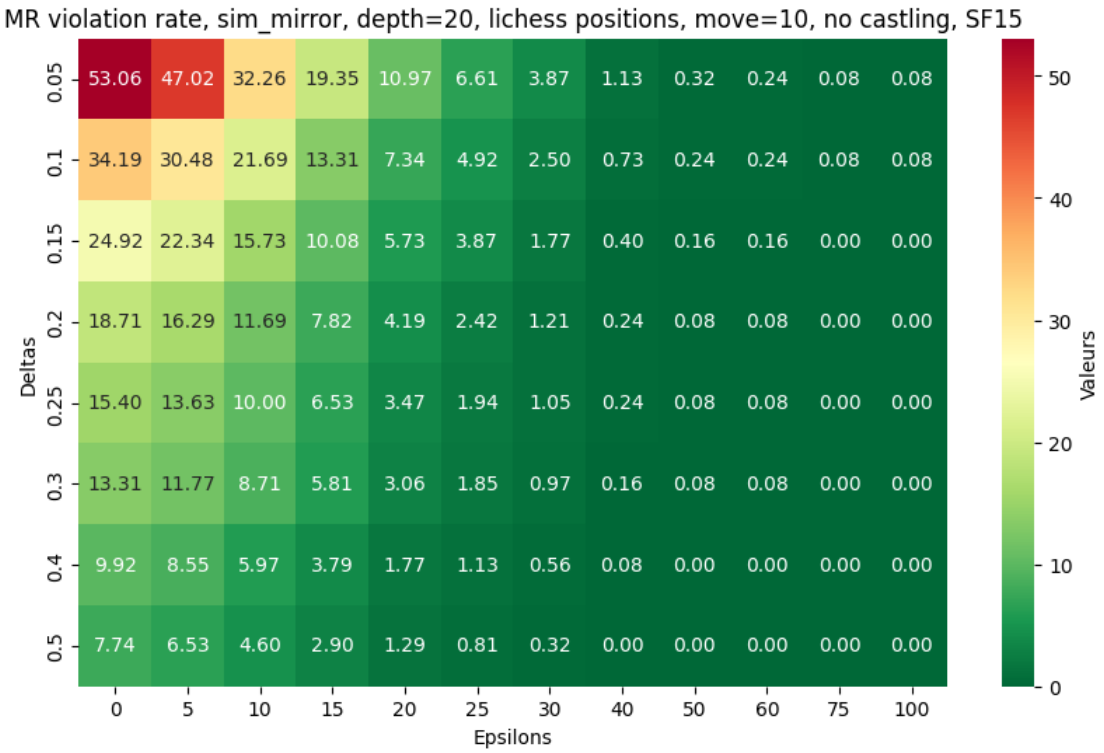
```
move = 10
```




**Lichess positions - All elos, no castling available**

[543]:
```
path = os.path.join('reals','ev_lichessAllElos-10_nocastlingsim_mirror_d_20.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ', lichess positions, move=10, no castling, SF15')
```

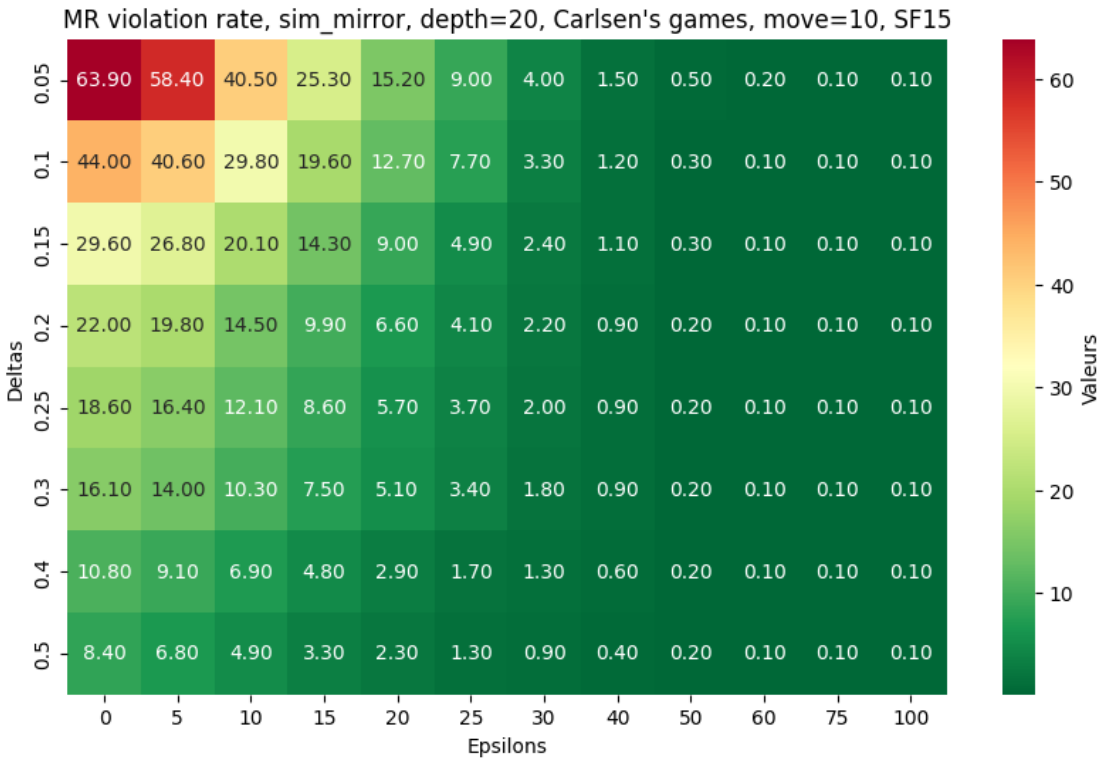
```
move = 10
```




### Carlsen's games

[547]:
```
path = os.path.join('reals','ev_Carlsen-10sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ", Carlsen's games, move=10, SF15")
```

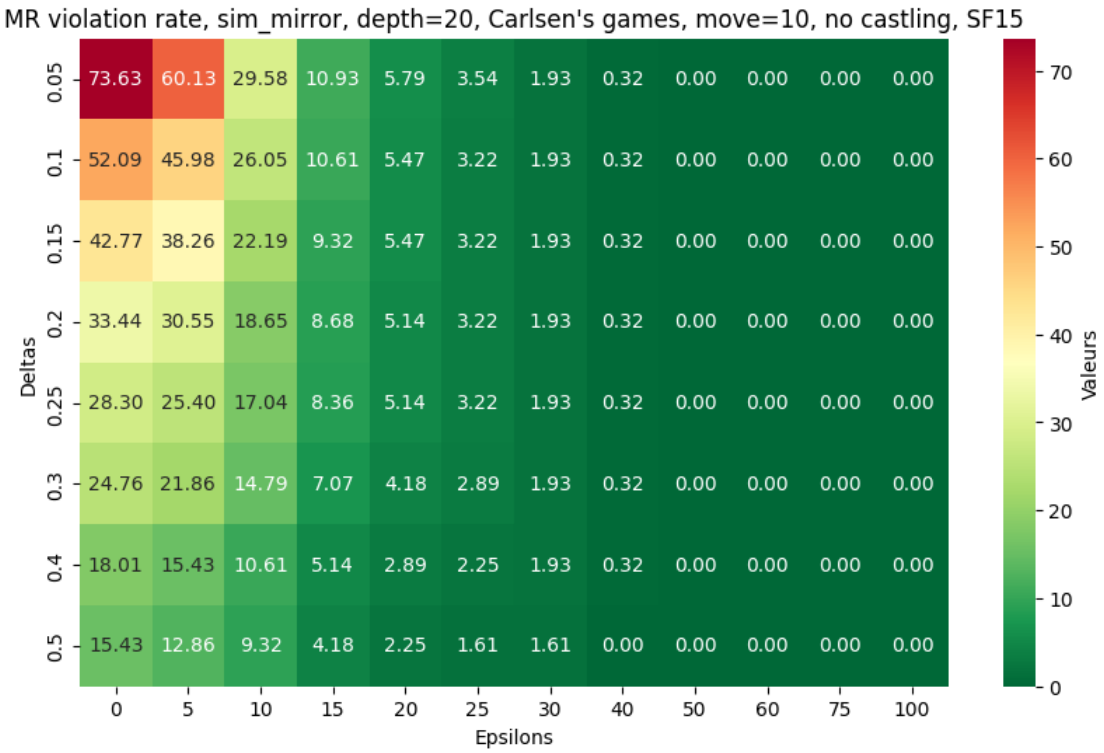
```
move = 10
```




**Carlsen's games, no castling available**

[548]:
```
path = os.path.join('reals','ev_Carlsen-10_nocastlingsim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs01510 = pickle.load(file)

print('move = 10')
tests(evs01510,0,20, ", Carlsen's games, move=10, no castling, SF15")
```

```
move = 10
```

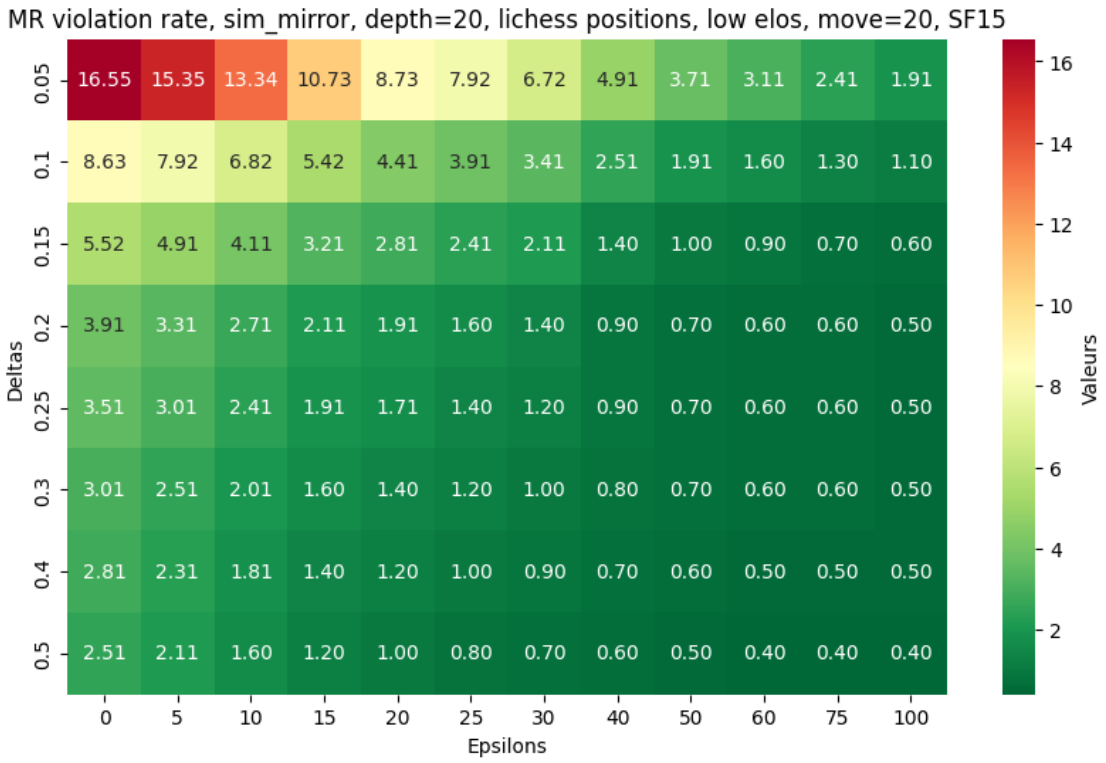



### Middlegames (move=20)

### Lichess positions - 1000 to 1500 elo rating

[550]:
```
path = os.path.join('reals','ev_lichess1000-1500-20sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ', lichess positions, low elos, move=20, SF15')
```

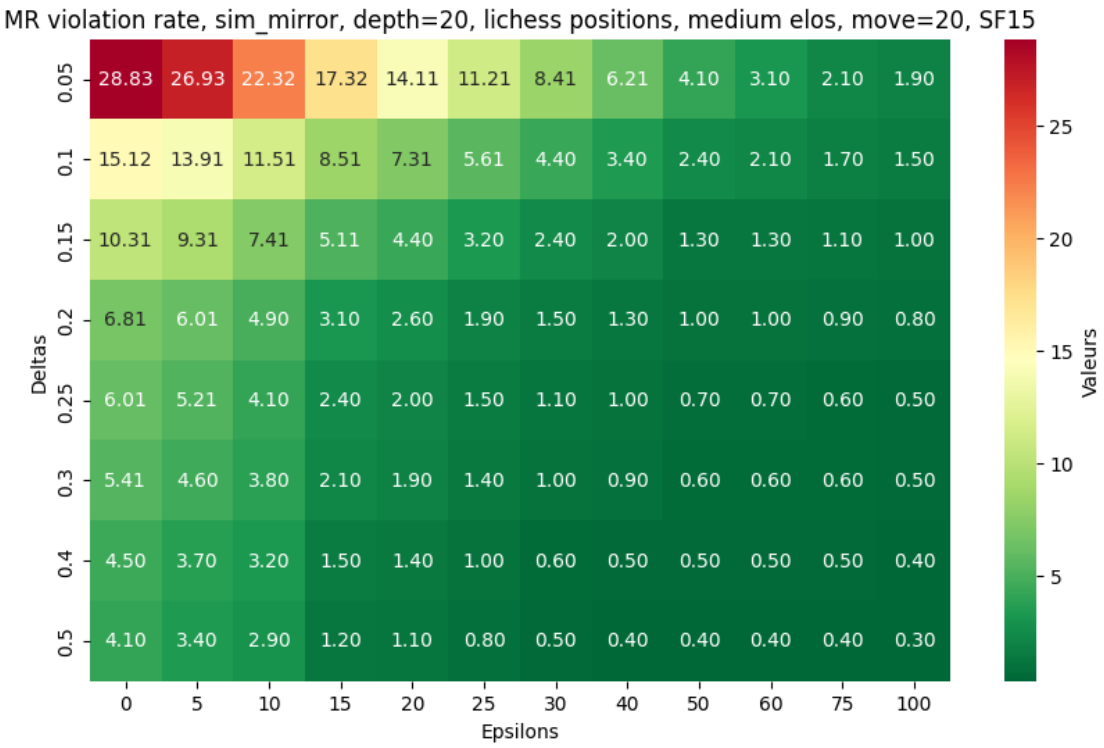
```
move = 20
```




**Lichess positions - 1500 to 2000 elo rating**

[551]:
```
path = os.path.join('reals','ev_lichess1500-2000-20sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ', lichess positions, medium elos, move=20, SF15')
```

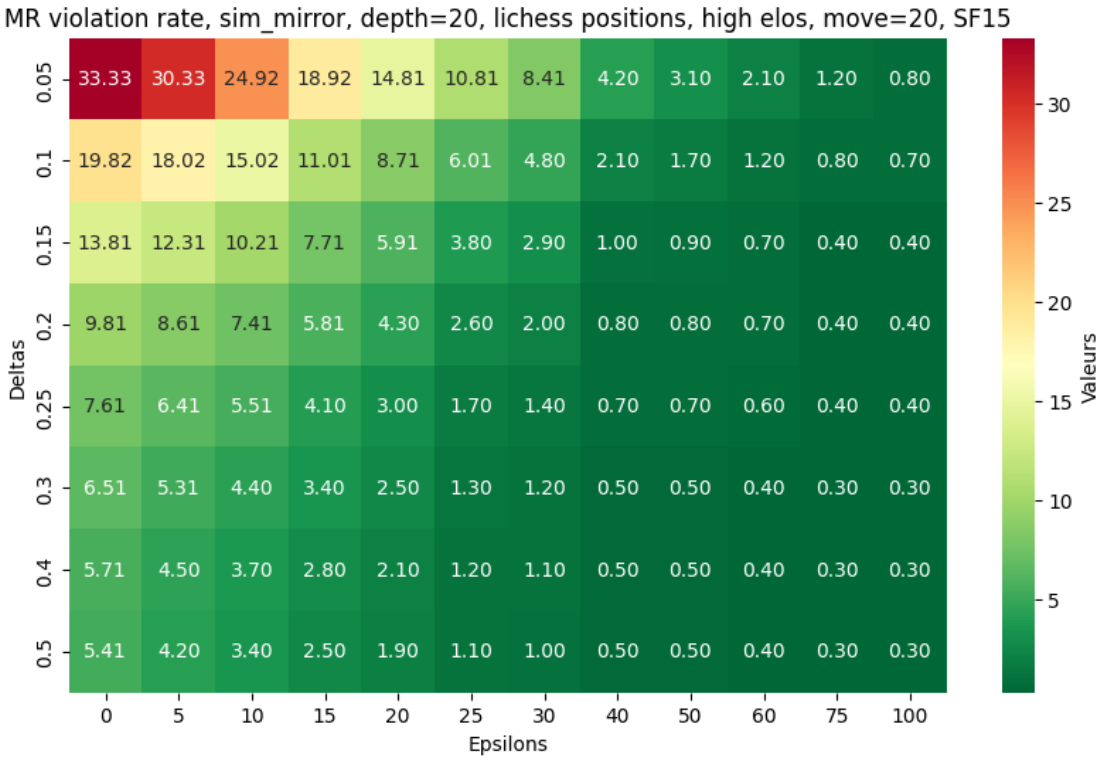
```
move = 20
```




**Lichess positions - 2000 to 2500 elo rating**

[552]:
```
path = os.path.join('reals','ev_lichess2000-2500-20sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ', lichess positions, high elos, move=20, SF15')
```

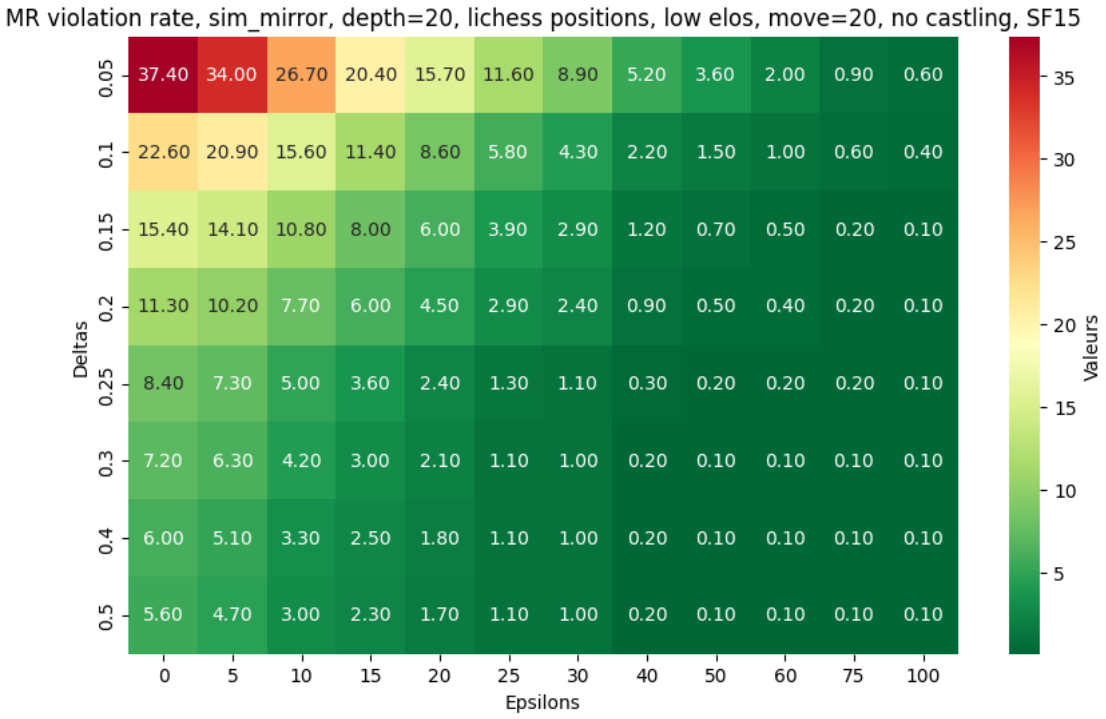
```
move = 20
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[553]:
```
path = os.path.join('reals','ev_lichess2000-2500-20_nocastlingsim_mirror_d_20.
  ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ', lichess positions, low elos, move=20, no castling, SF15')
```

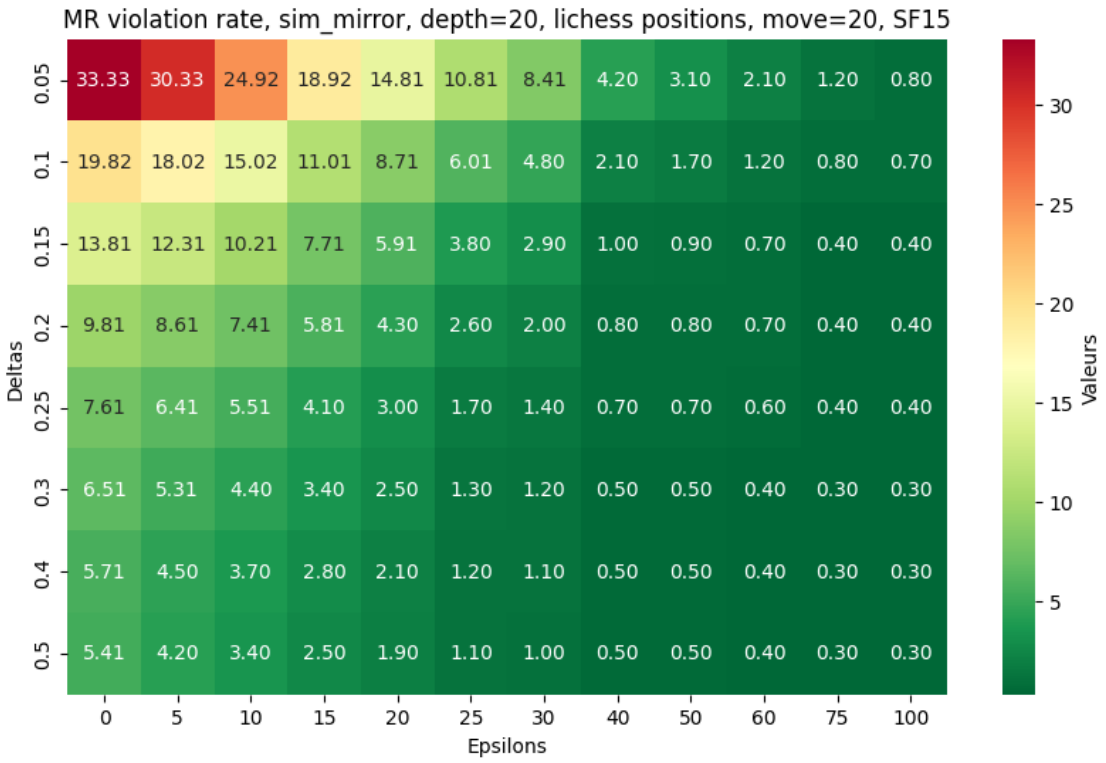
```
move = 20
```




**Lichess positions - All elos**

[554]:
```
path = os.path.join('reals','ev_lichess2000-2500-20sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ', lichess positions, move=20, SF15')
```

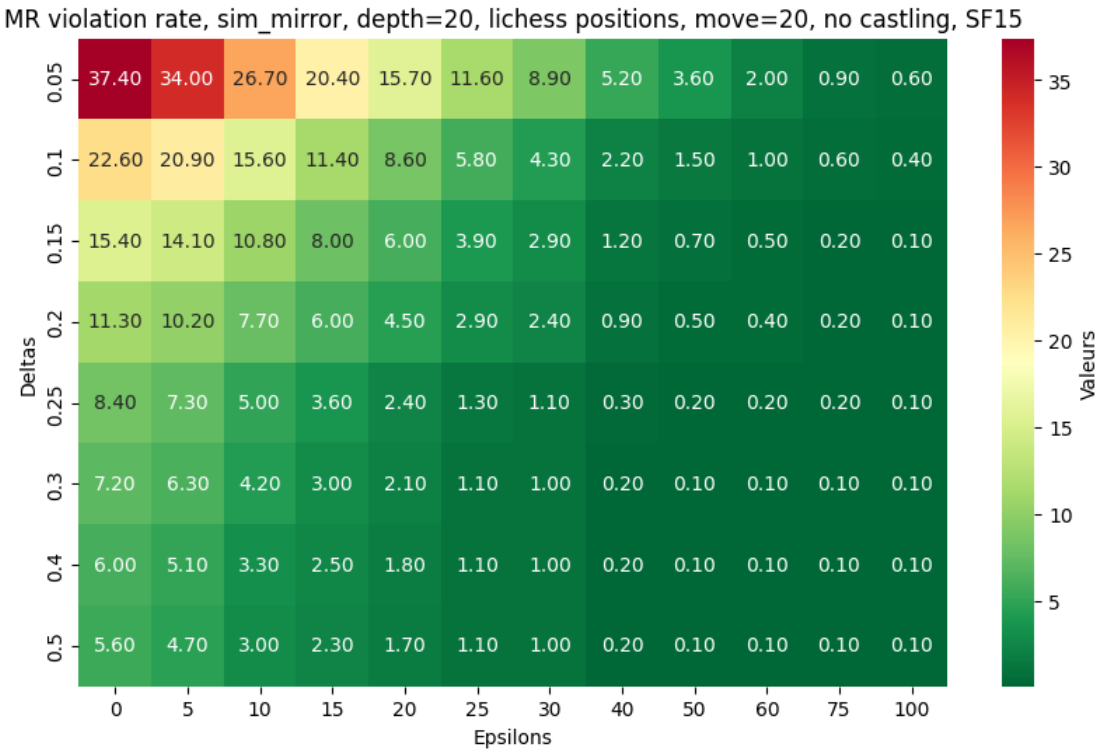
```
move = 20
```




**Lichess positions - All elos, no castling available**

[555]:
```
path = os.path.join('reals','ev_lichess2000-2500-20_nocastlingsim_mirror_d_20.
  ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ', lichess positions, move=20, no castling, SF15')
```

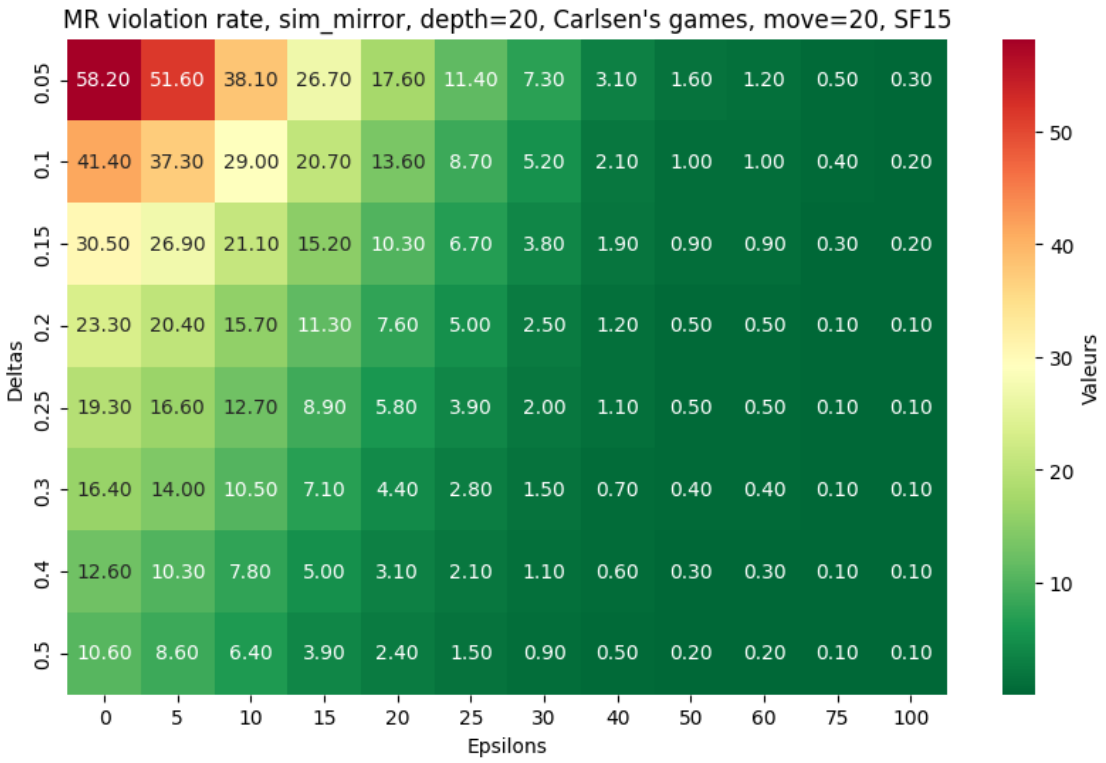
```
move = 20
```




**Carlsen's games**

[557]:
```
path = os.path.join('reals','ev_Carlsen-20sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ", Carlsen's games, move=20, SF15")
```

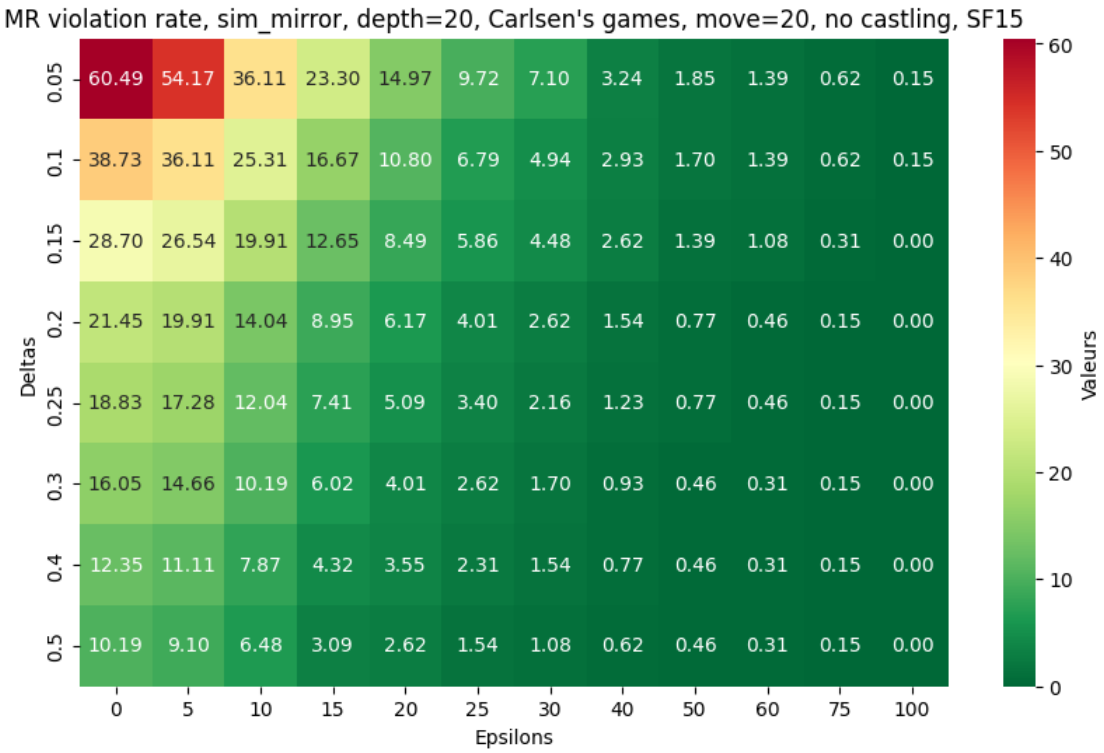
```
move = 20
```




**Carlsen's games, no castling available**

[559]:
```
path = os.path.join('reals','ev_Carlsen-20_nocastlingsim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs01520 = pickle.load(file)

print('move = 20')
tests(evs01520,0,20, ", Carlsen's games, move=20, no castling, SF15")
```

```
move = 20
```

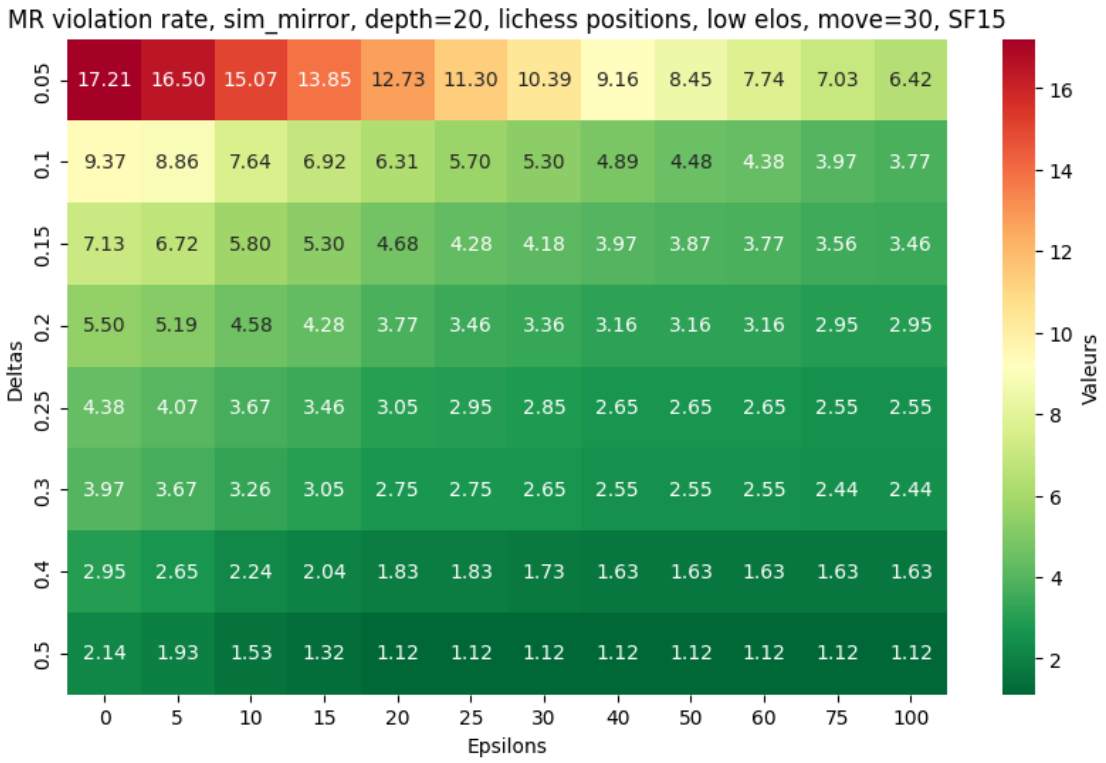



### Middle/Endgames (move=30)

### Lichess positions - 1000 to 1500 elo rating

[560]:
```
path = os.path.join('reals','ev_lichess1000-1500-30sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, low elos, move=30, SF15")
```

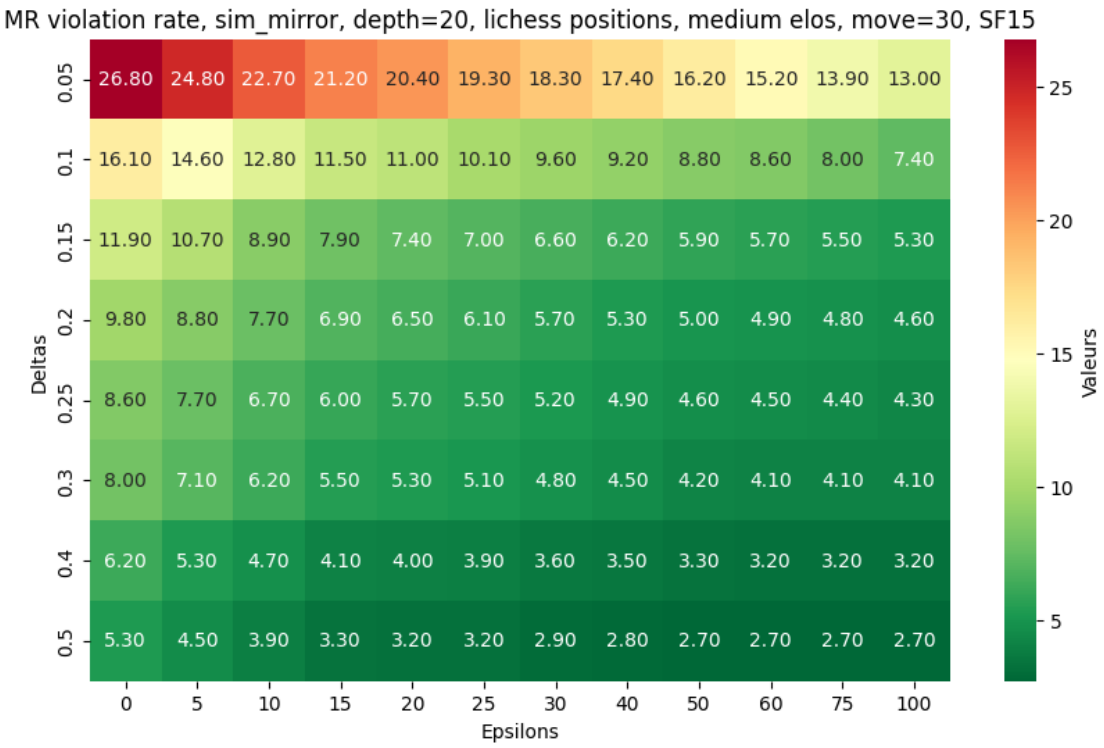
```
move = 30
```




**Lichess positions - 1500 to 2000 elo rating**

[561]:
```
path = os.path.join('reals','ev_lichess1500-2000-30sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, medium elos, move=30, SF15")
```

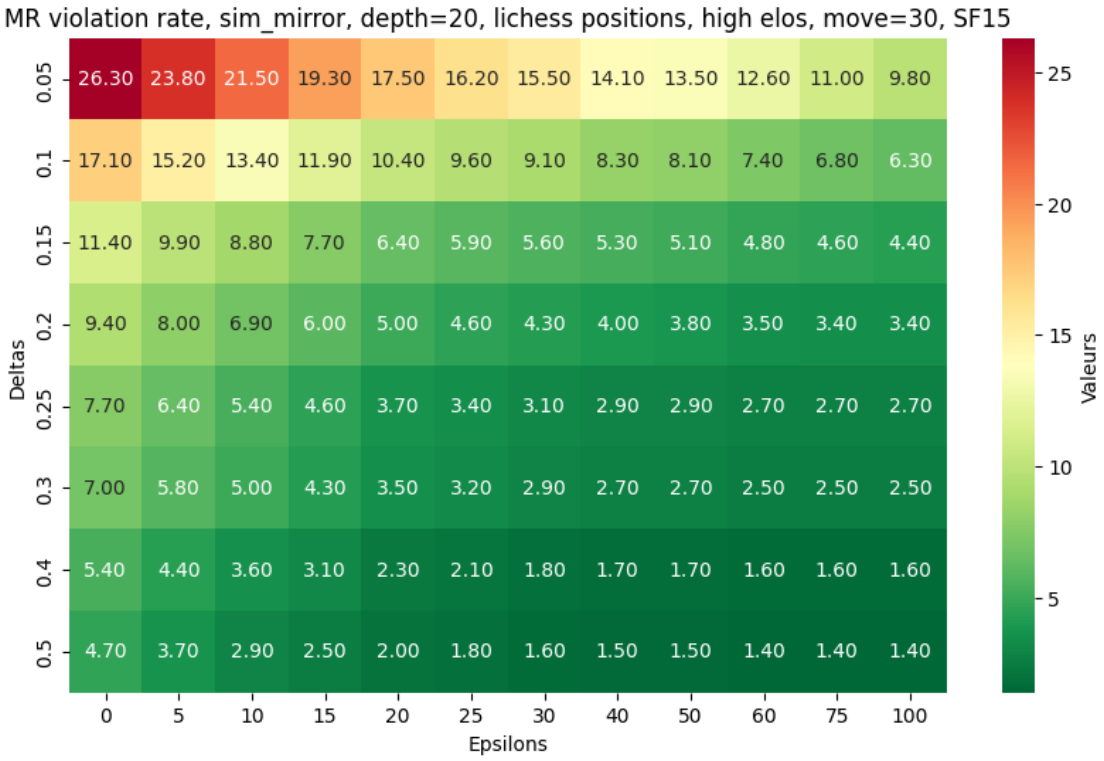
```
move = 30
```




**Lichess positions - 2000 to 2500 elo rating**

[562]:
```
path = os.path.join('reals','ev_lichess2000-2500-30sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, high elos, move=30, SF15")
```

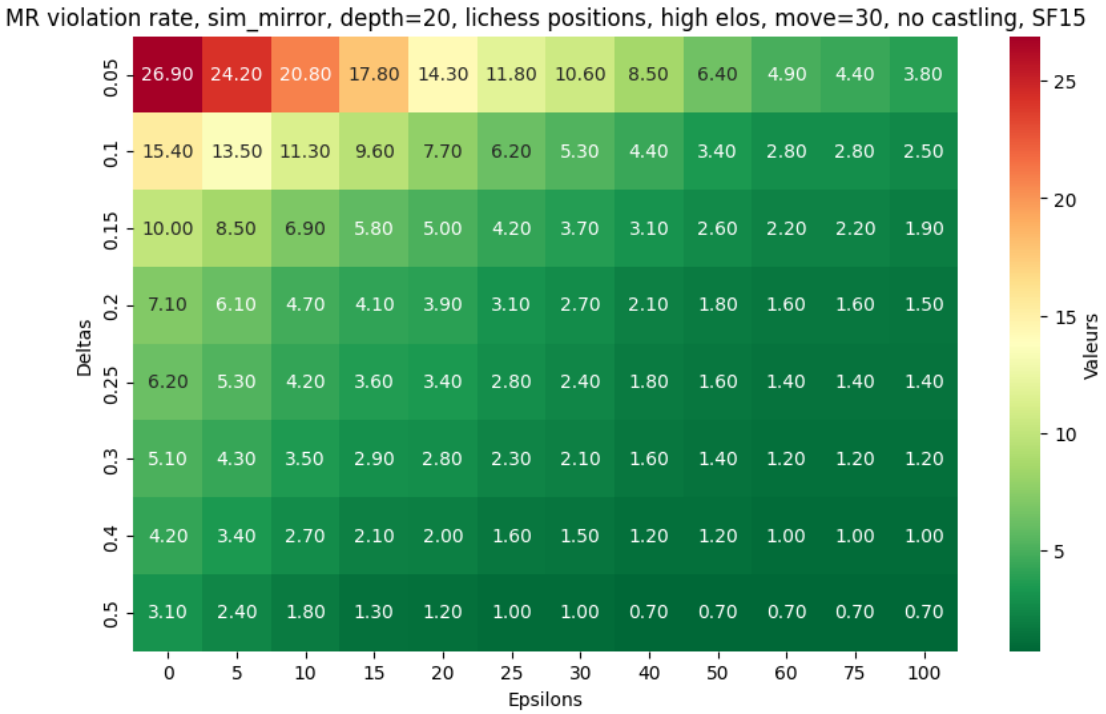
```
move = 30
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[563]:
```
path = os.path.join('reals','ev_lichess2000-2500-30_nocastlingsim_mirror_d_20.
  ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, high elos, move=30, no castling, SF15")
```

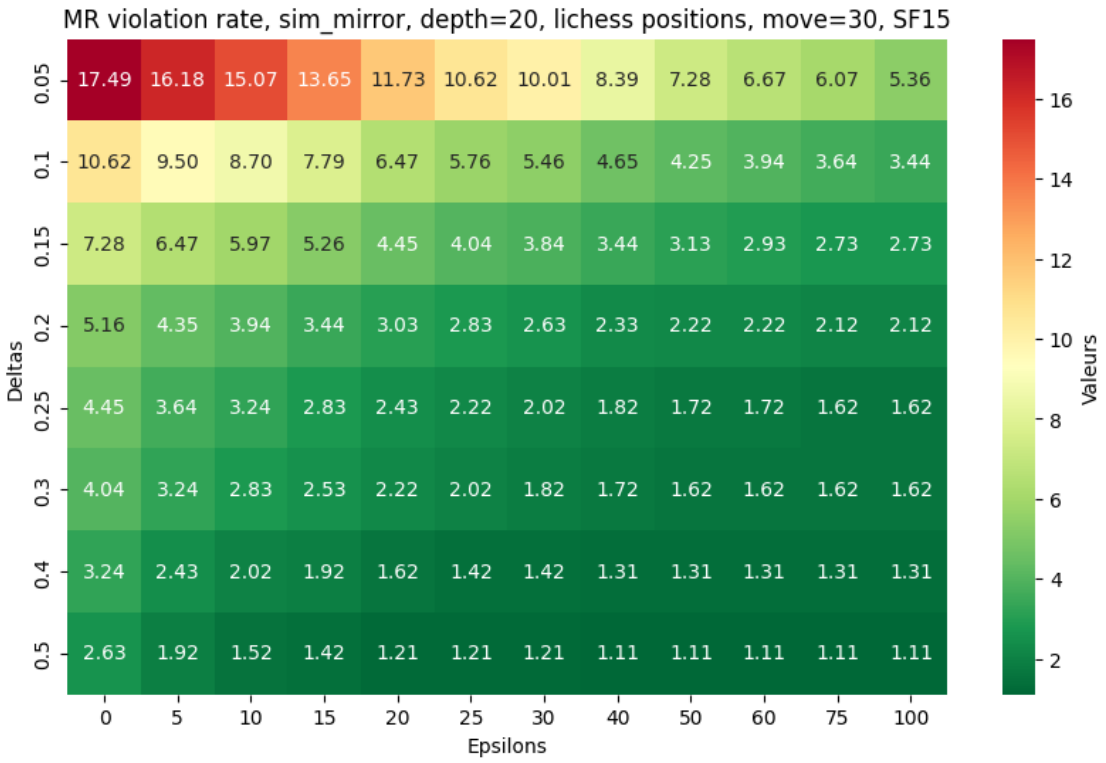
```
move = 30
```




**Lichess positions - All elos**

[564]:
```
path = os.path.join('reals','ev_lichessAllElos-30sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, move=30, SF15")
```

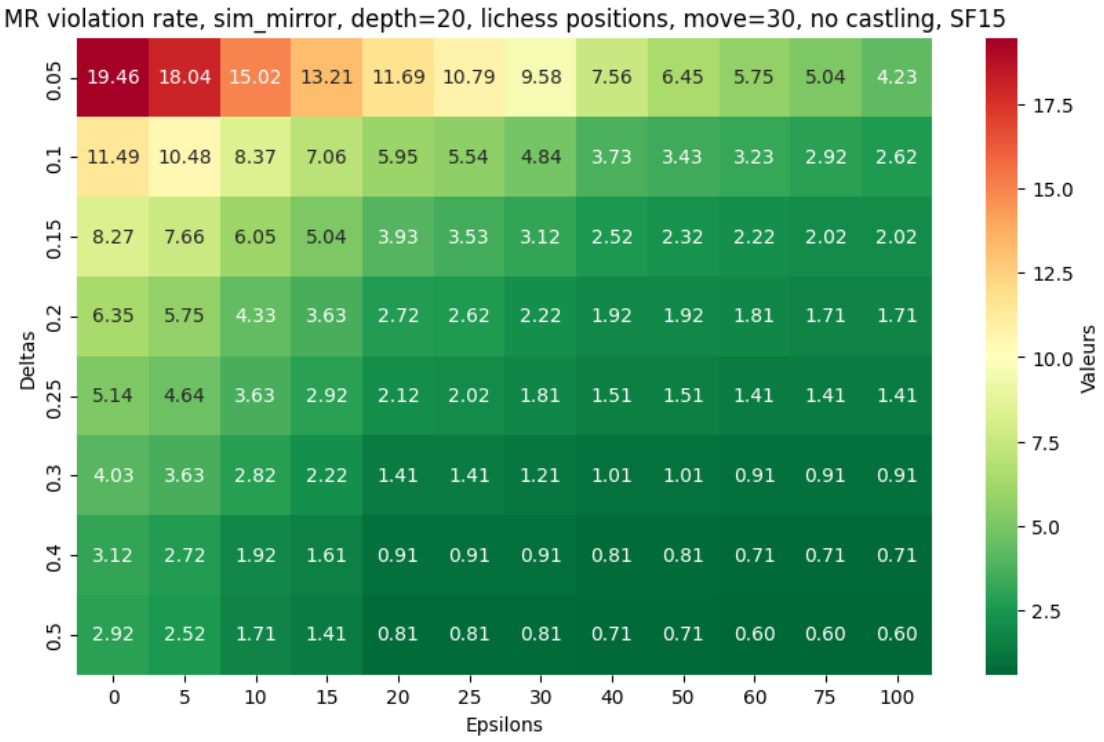
```
move = 30
```




**Lichess positions - All elos, no castling available**

[565]:
```
path = os.path.join('reals','ev_lichessAllElos-30_nocastlingsim_mirror_d_20.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, move=30, no castling, SF15")
```

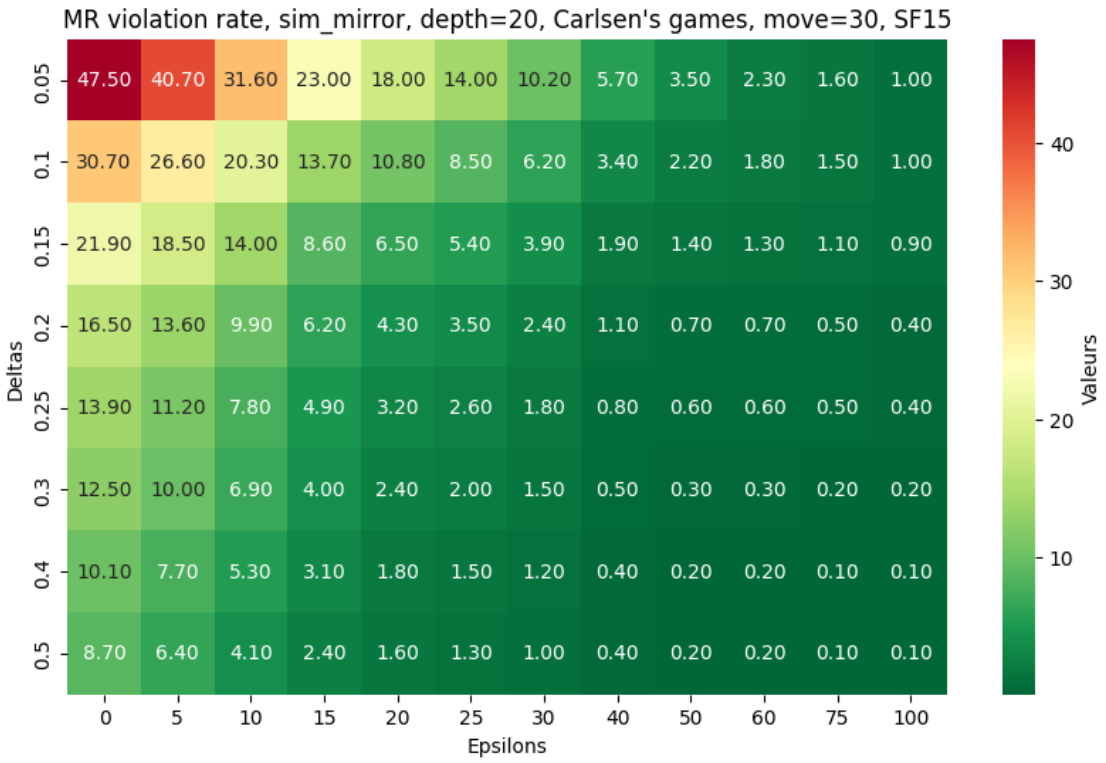
```
move = 30
```




### Carlsen's games

[566]:
```
path = os.path.join('reals','ev_Carlsen-30sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", Carlsen's games, move=30, SF15")
```

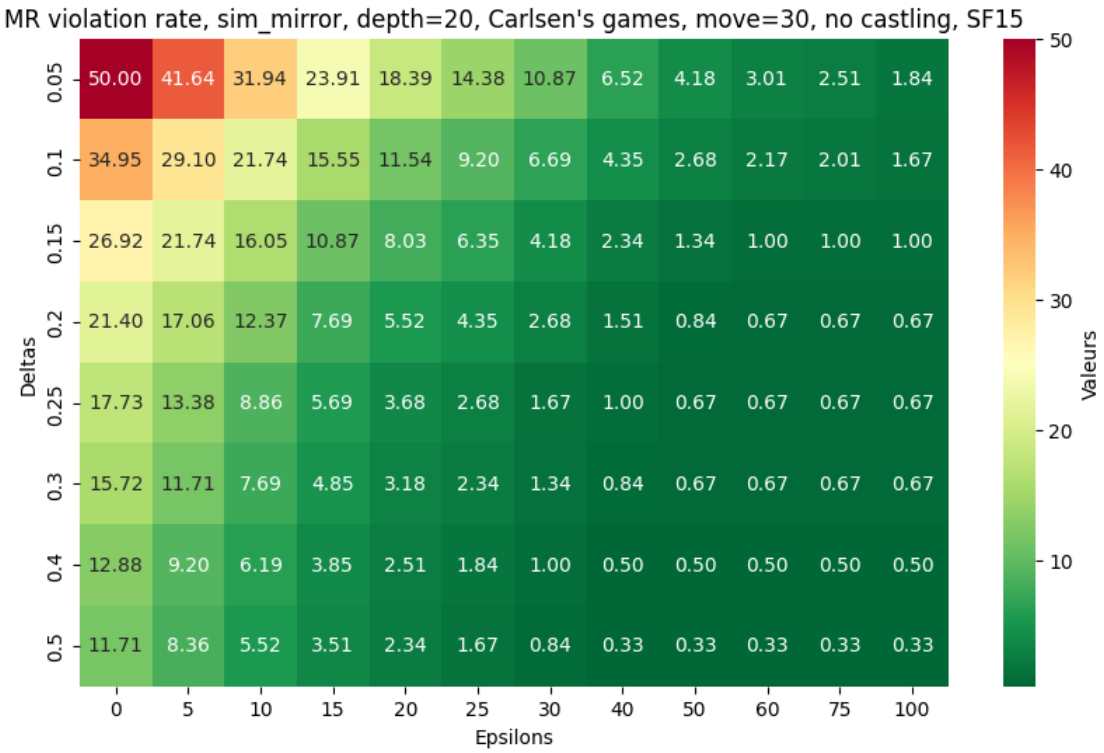
```
move = 30
```




**Carlsen's games, no castling available**

[567]:
```
path = os.path.join('reals','ev_Carlsen-30_nocastlingsim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs01530 = pickle.load(file)

print('move = 30')
tests(evs01530,0,20, ", Carlsen's games, move=30, no castling, SF15")
```

```
move = 30
```

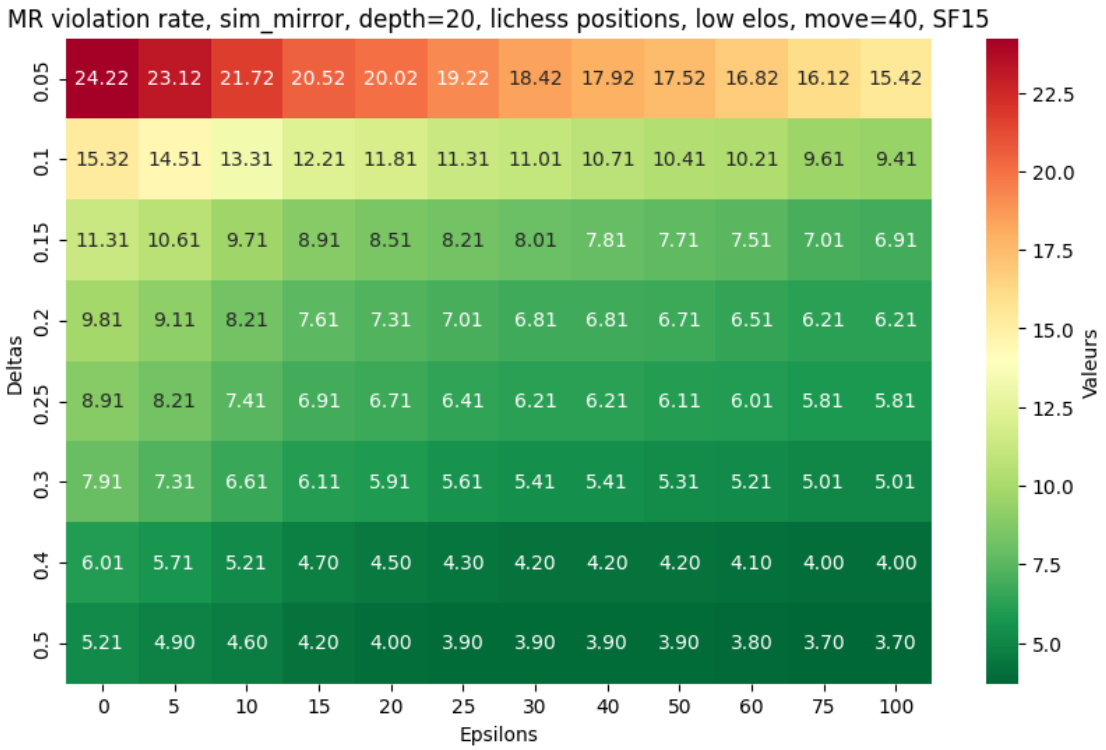



### Endgames (move=40)

### Lichess positions - 1000 to 1500 elo rating

[568]:
```
path = os.path.join('reals','ev_lichess1000-1500-40sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, low elos, move=40, SF15")
```

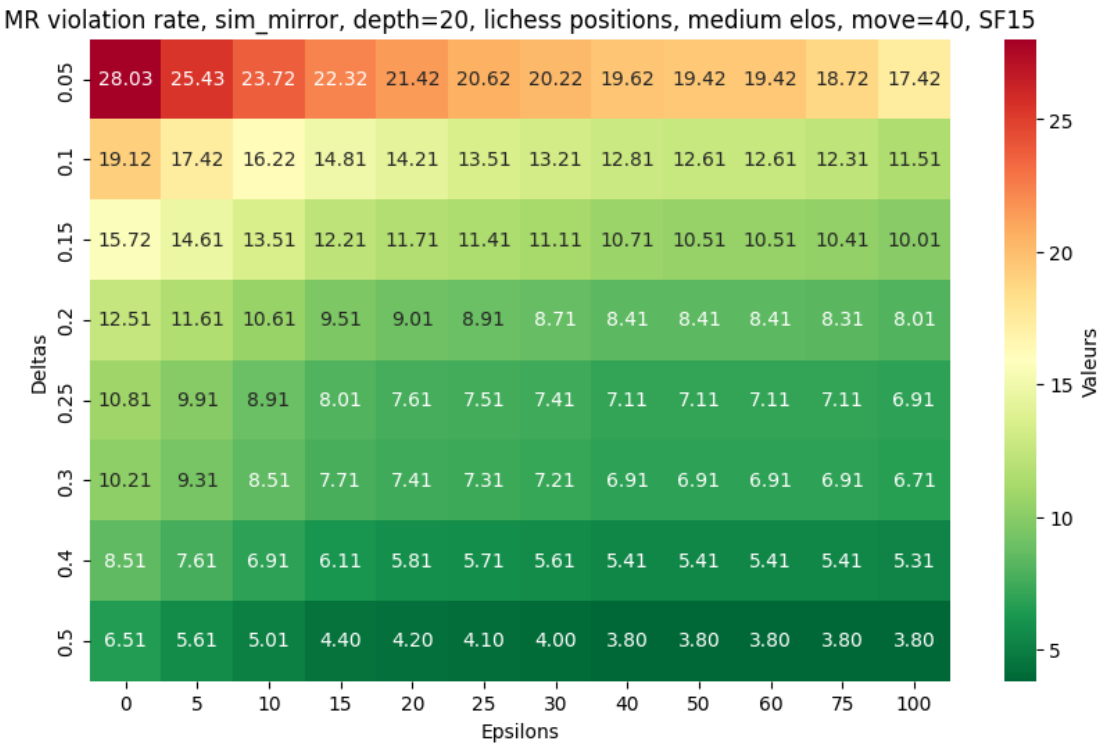
```
move = 40
```




**Lichess positions - 1500 to 2000 elo rating**

[569]:
```
path = os.path.join('reals','ev_lichess1500-2000-40sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, medium elos, move=40, SF15")
```

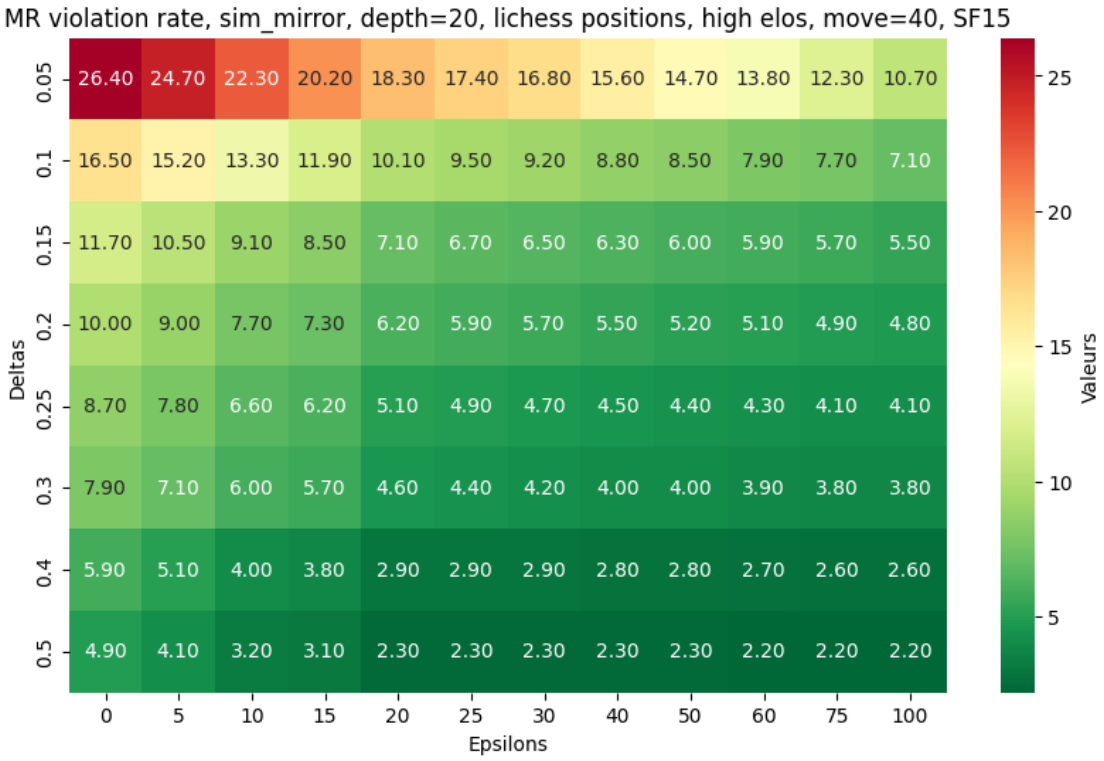
```
move = 40
```




**Lichess positions - 2000 to 2500 elo rating**

[570]:
```
path = os.path.join('reals','ev_lichess2000-2500-40sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, high elos, move=40, SF15")
```

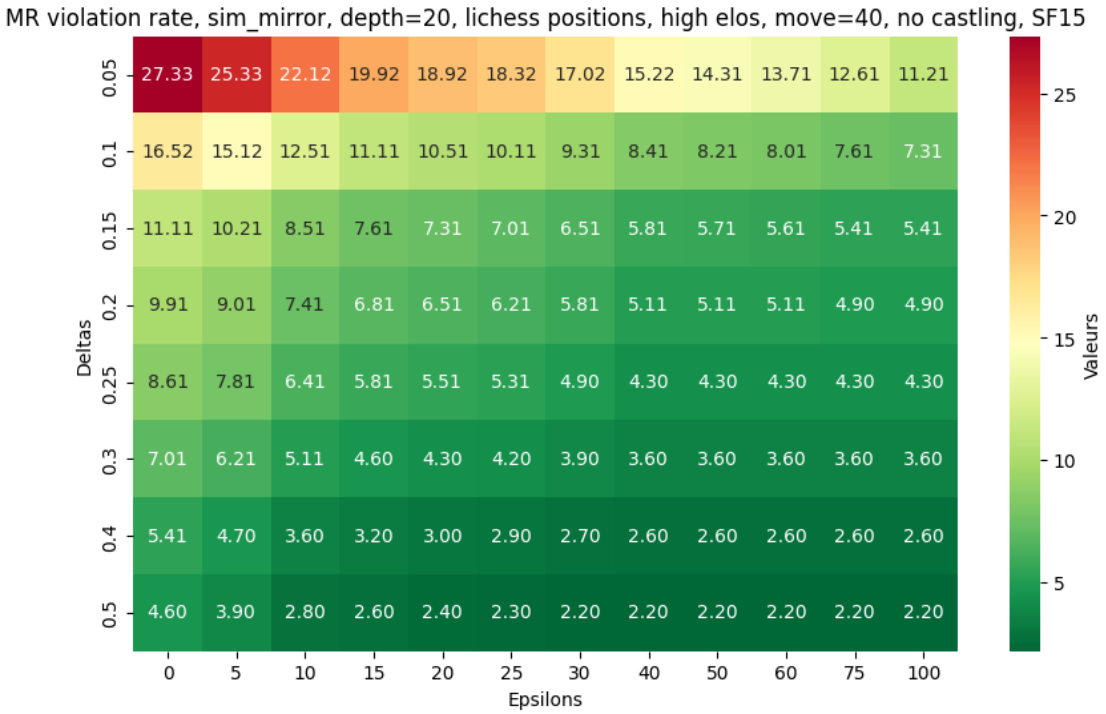
```
move = 40
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[571]:
```
path = os.path.join('reals','ev_lichess2000-2500-40_nocastlingsim_mirror_d_20.
  ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, high elos, move=40, no castling, SF15")
```

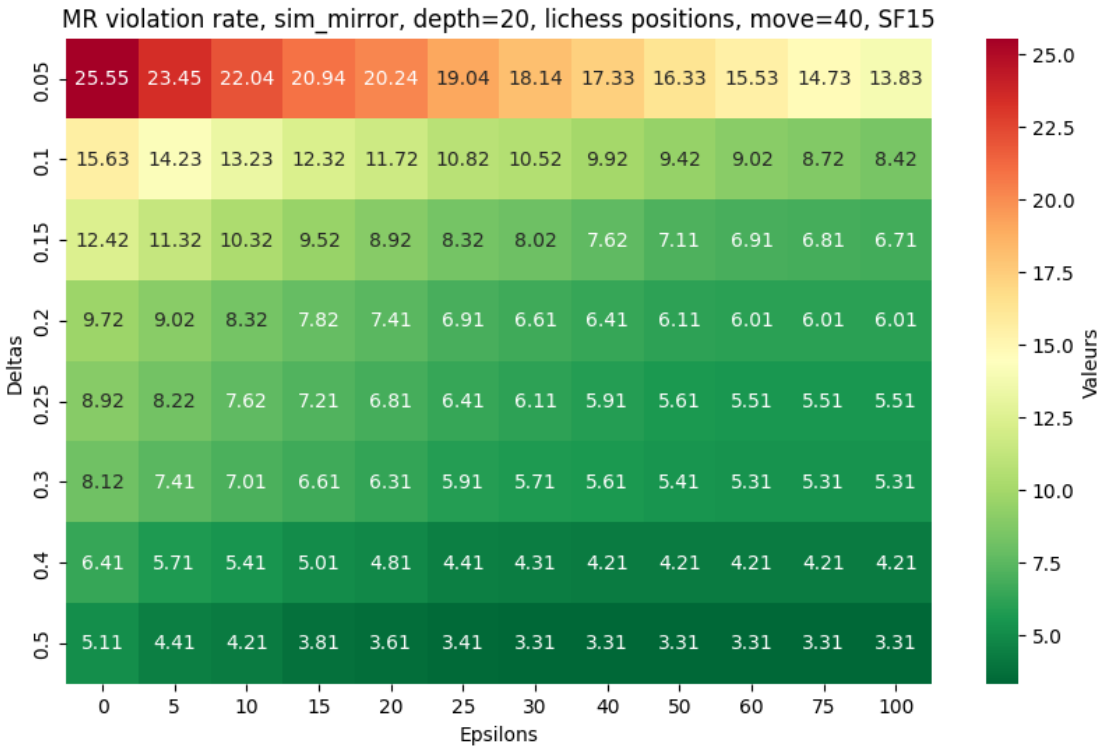
```
move = 40
```




**Lichess positions - All elos**

[572]:
```
path = os.path.join('reals','ev_lichessAllElos-40sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, move=40, SF15")
```

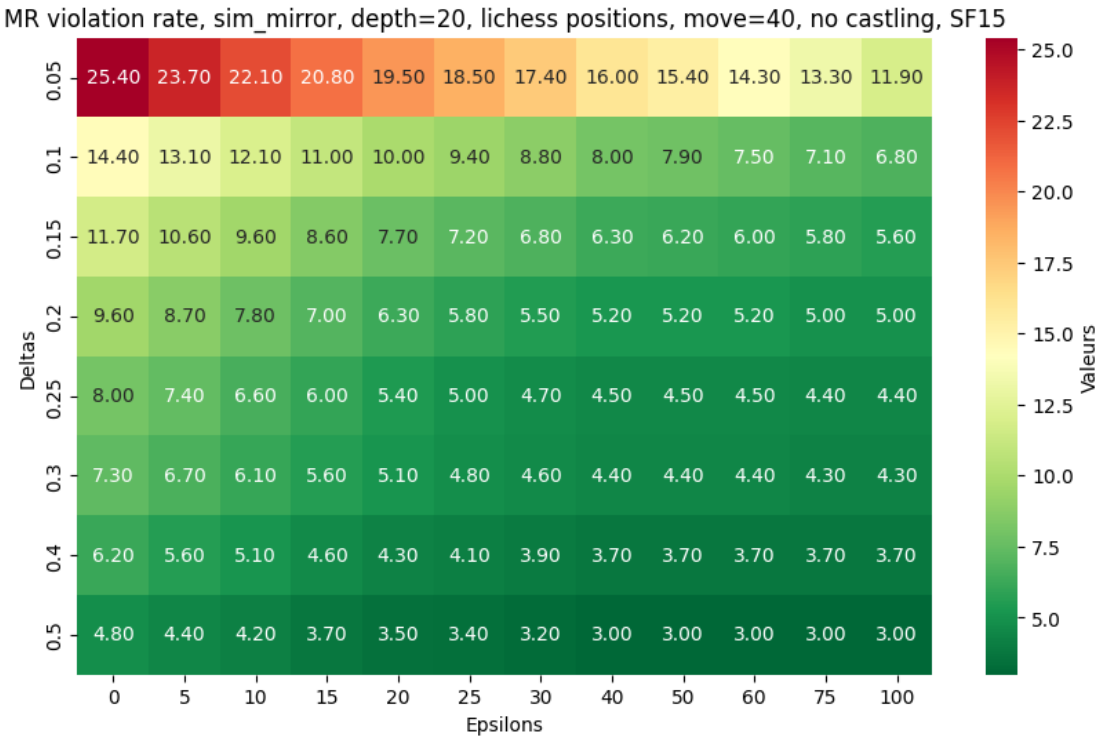
```
move = 40
```




**Lichess positions - All elos, no castling available**

[573]:
```
path = os.path.join('reals','ev_lichessAllElos-40_nocastlingsim_mirror_d_20.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, move=40, no castling, SF15")
```

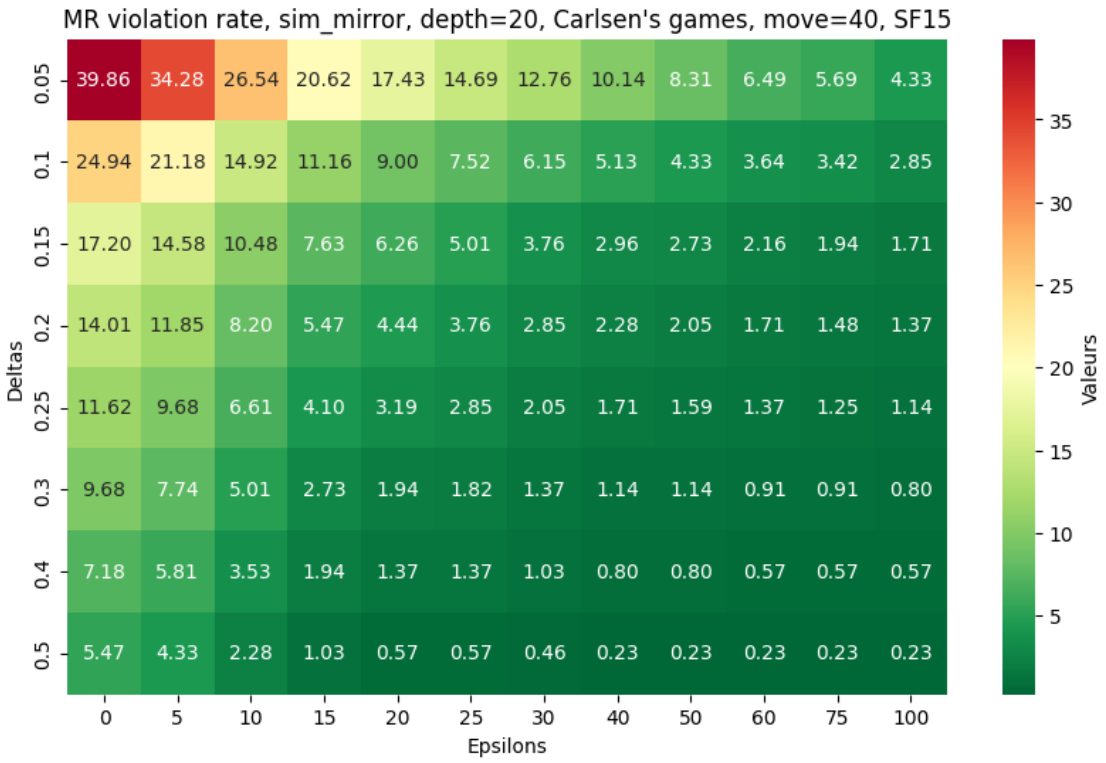
```
move = 40
```




### Carlsen's games

[574]:
```
path = os.path.join('reals','ev_Carlsen-40sim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", Carlsen's games, move=40, SF15")
```

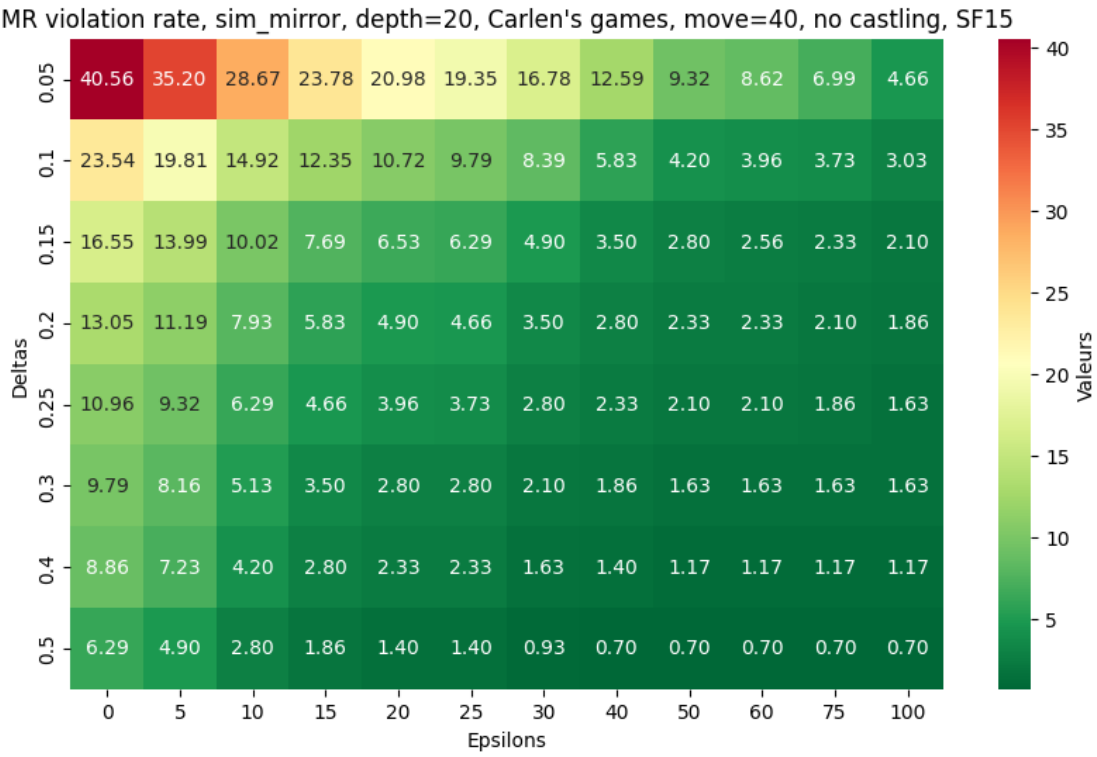
```
move = 40
```




**Carlsen's games, no castling available**

[575]:
```
path = os.path.join('reals','ev_Carlsen-40_nocastlingsim_mirror_d_20.pkl')
with open(path, 'rb') as file:
    evs01540 = pickle.load(file)

print('move = 40')
tests(evs01540,0,20, ", Carlen's games, move=40, no castling, SF15")
```

```
move = 40
```



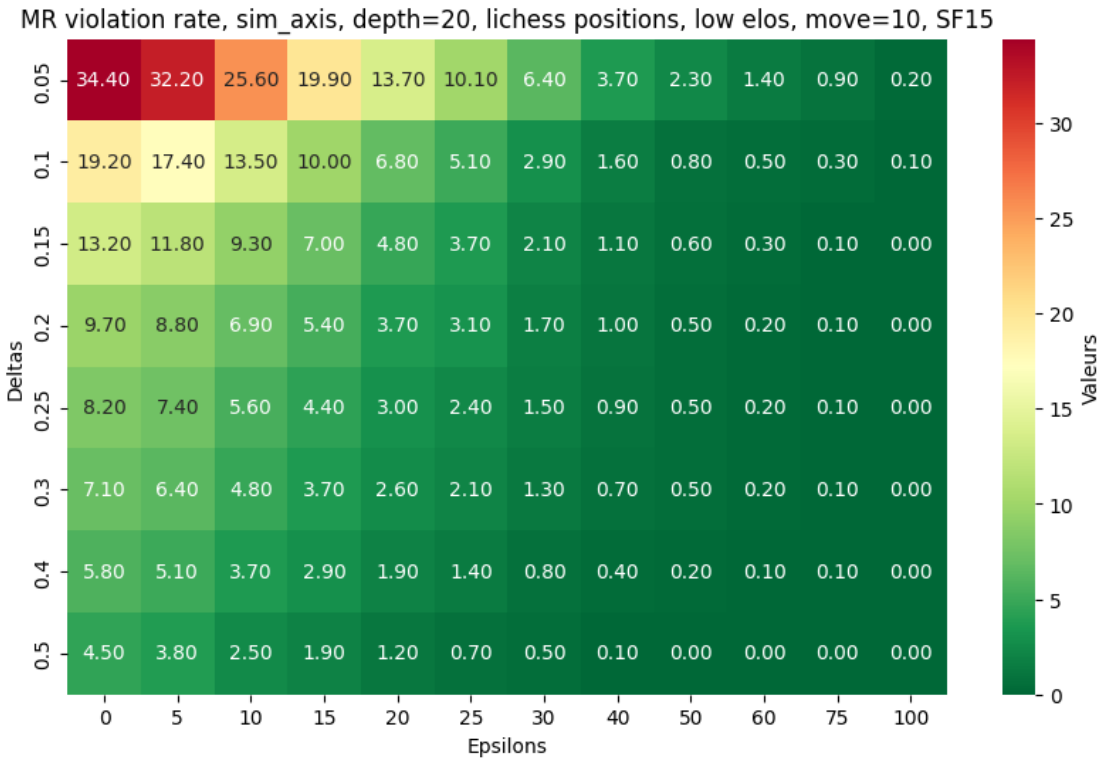

### 0.11.2 sim_axis

**Openings (move=10)**

**Lichess positions - 1000 to 1500 elo rating**

[576]:
```
path = os.path.join('reals','ev_lichess1000-1500-10sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, low elos, move=10, SF15")
```

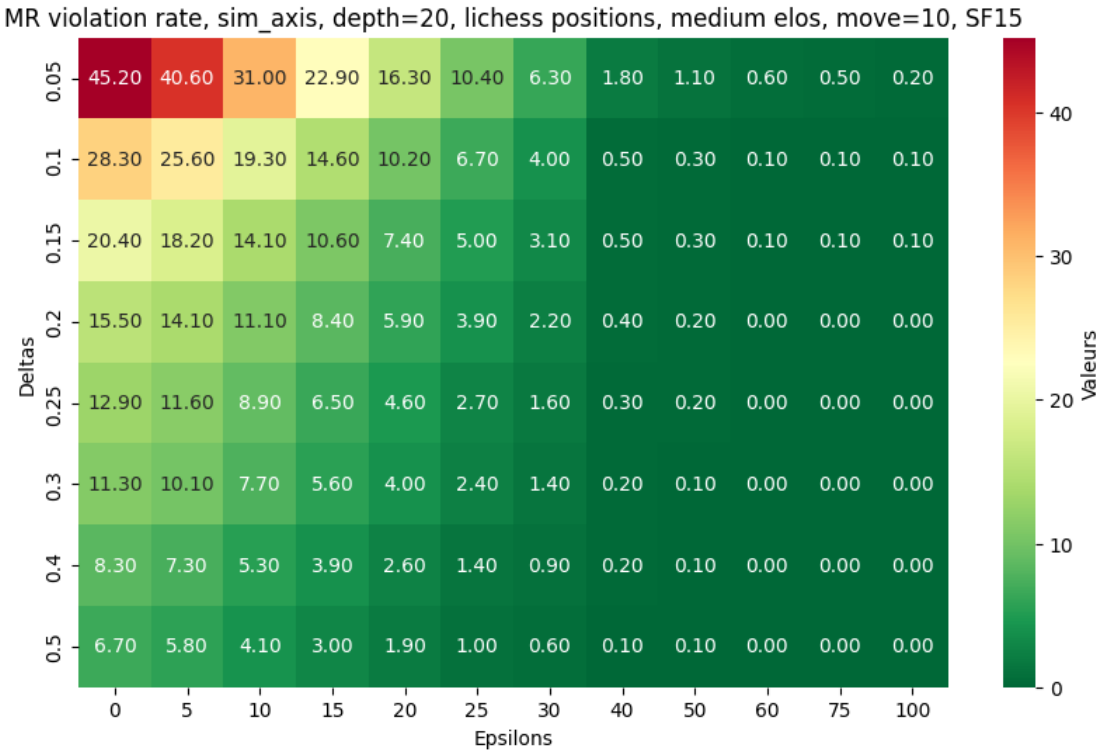
```
move = 10
```




**Lichess positions - 1500 to 2000 elo rating**

[577]:
```
path = os.path.join('reals','ev_lichess1500-2000-10sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, medium elos, move=10, SF15")
```

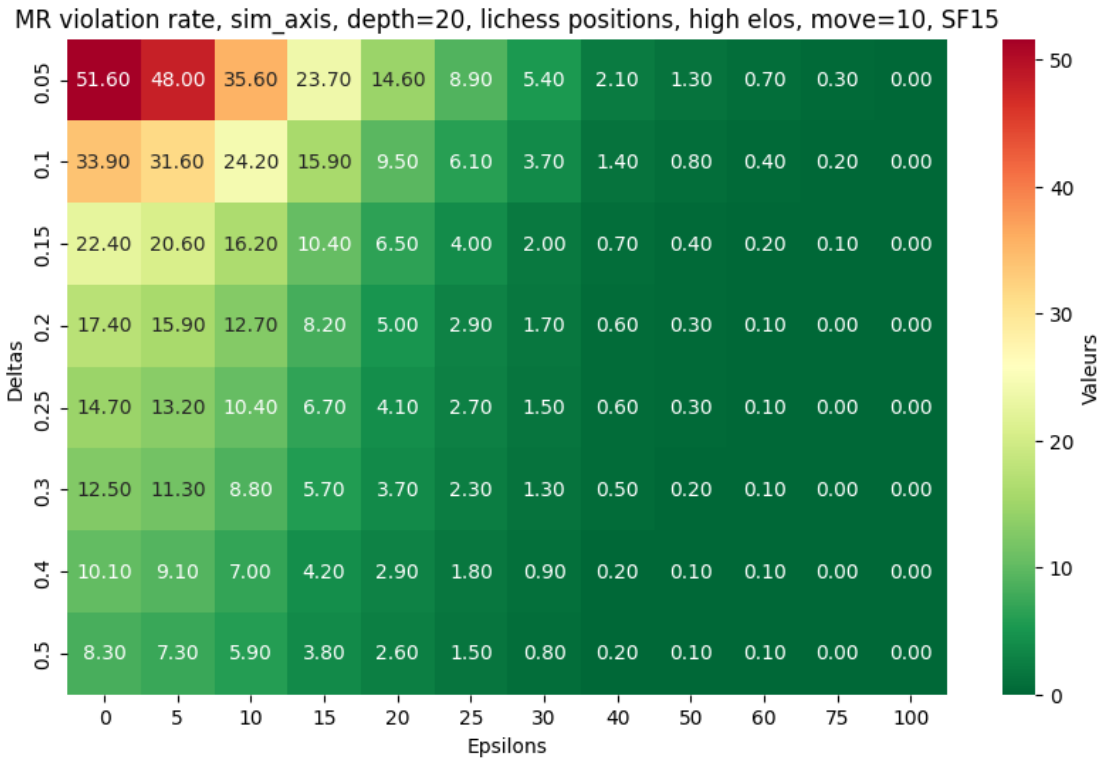
```
move = 10
```




**Lichess positions - 2000 to 2500 elo rating**

[578]:
```
path = os.path.join('reals','ev_lichess2000-2500-10sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, high elos, move=10, SF15")
```

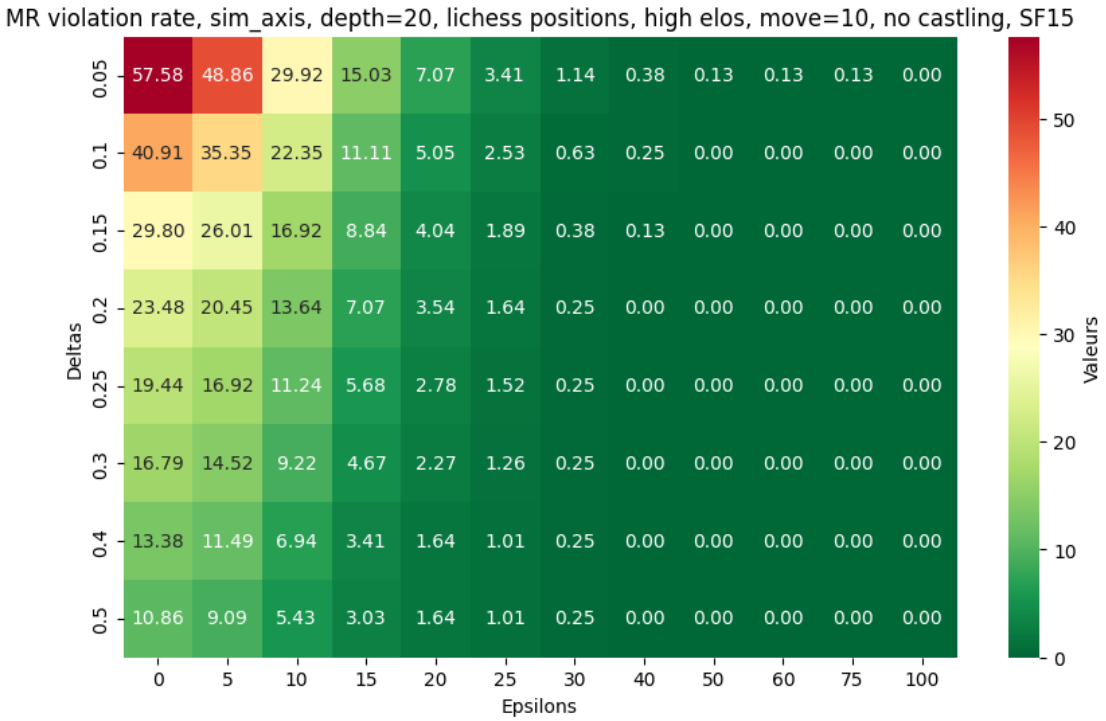
```
move = 10
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[719]:
```
path = os.path.join('reals','ev_lichess2000-2500-10_nocastlingsim_axis_d_20.
 ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)


print('move = 10')
tests(evs,1,20, ", lichess positions, high elos, move=10, no castling, SF15")
```

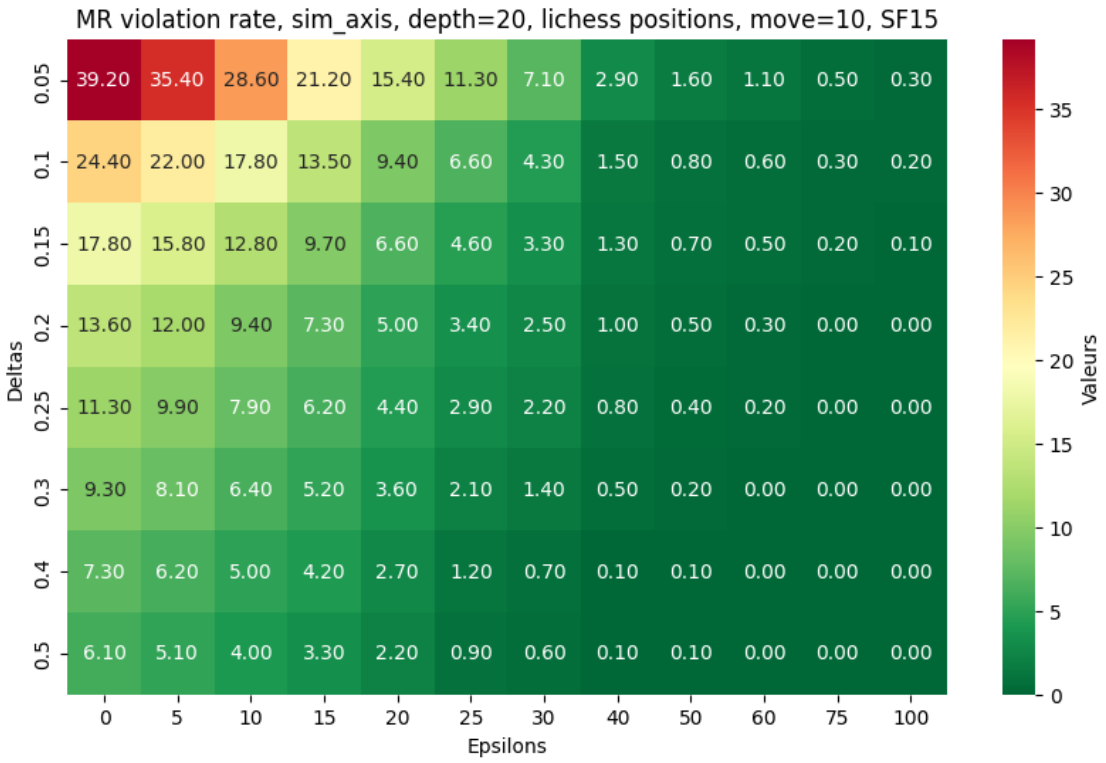
```
792
move = 10
```




**Lichess positions - All elos**

[580]:
```
path = os.path.join('reals','ev_lichessAllElos-10sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, move=10, SF15")
```

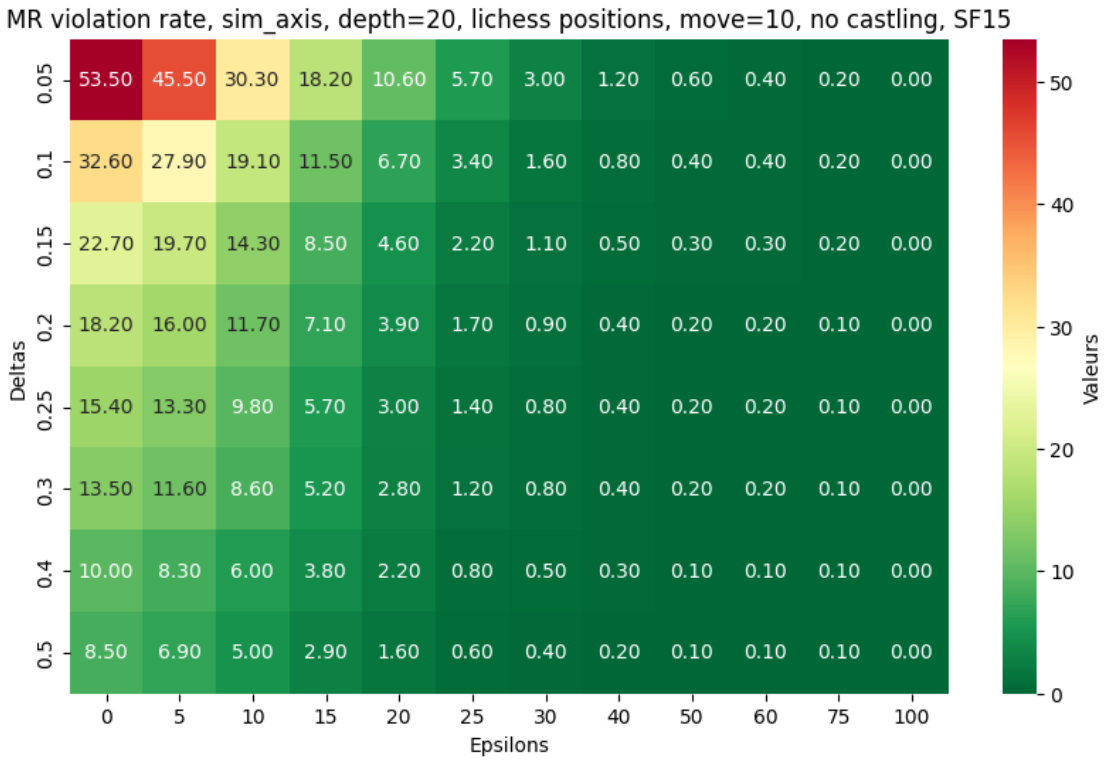
```
move = 10
```




**Lichess positions - All elos, no castling available**

[718]:
```
path = os.path.join('reals','ev_lichessAllElos-10_nocastlingsim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, move=10, no castling, SF15")
```

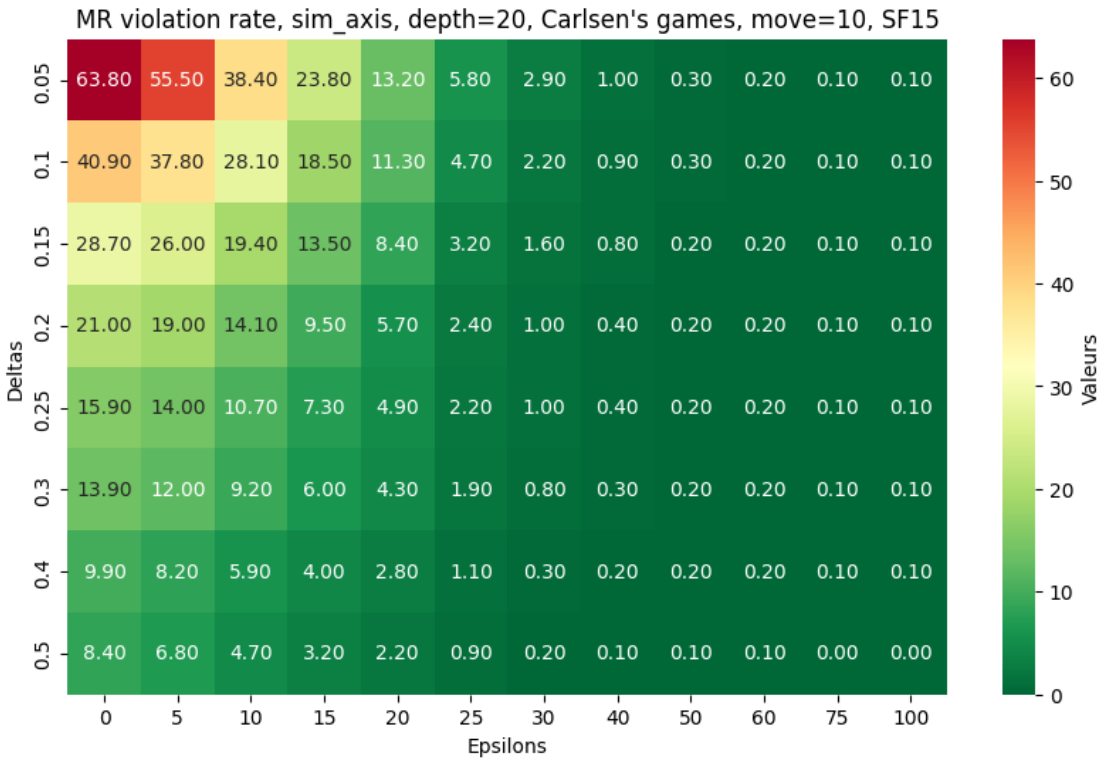
```
1000
move = 10
```




### Carlsen's games

[582]:
```
path = os.path.join('reals','ev_Carlsen-10sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", Carlsen's games, move=10, SF15")
```

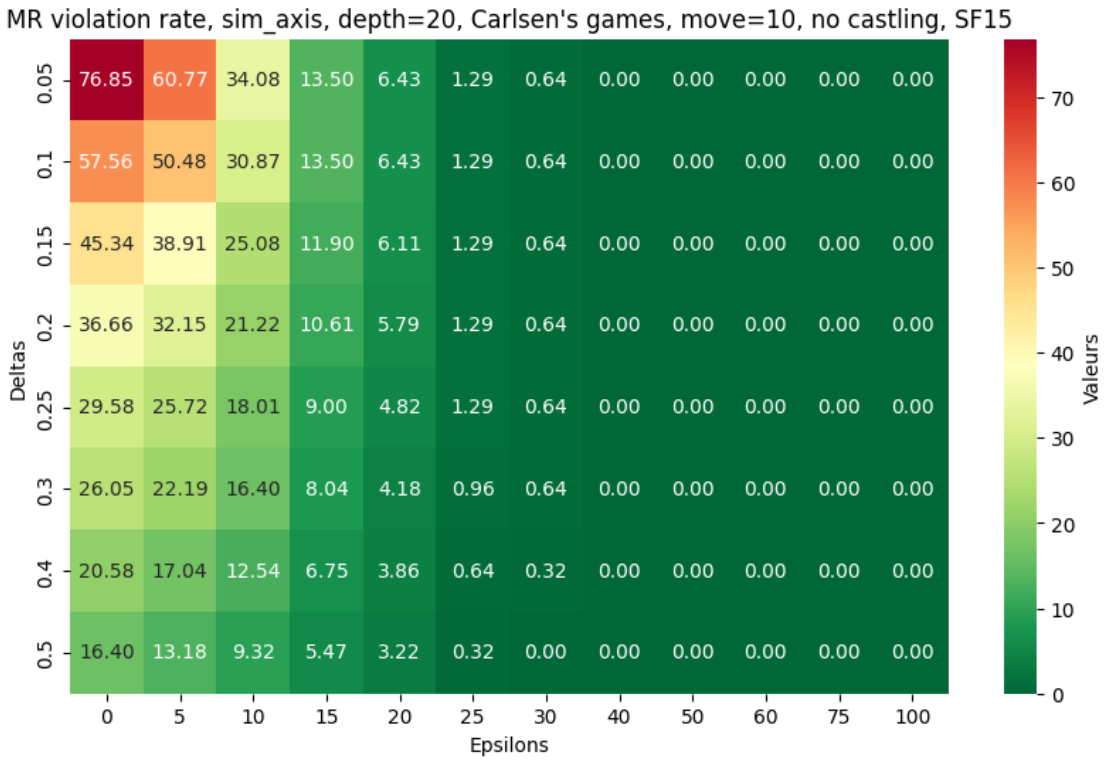
```
move = 10
```




**Carlsen's games, no castling available**

[721]:
```
path = os.path.join('reals','ev_Carlsen-10_nocastlingsim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs11510 = pickle.load(file)

print('move = 10')
tests(evs11510,1,20, ", Carlsen's games, move=10, no castling, SF15")
```

```
311
move = 10
```

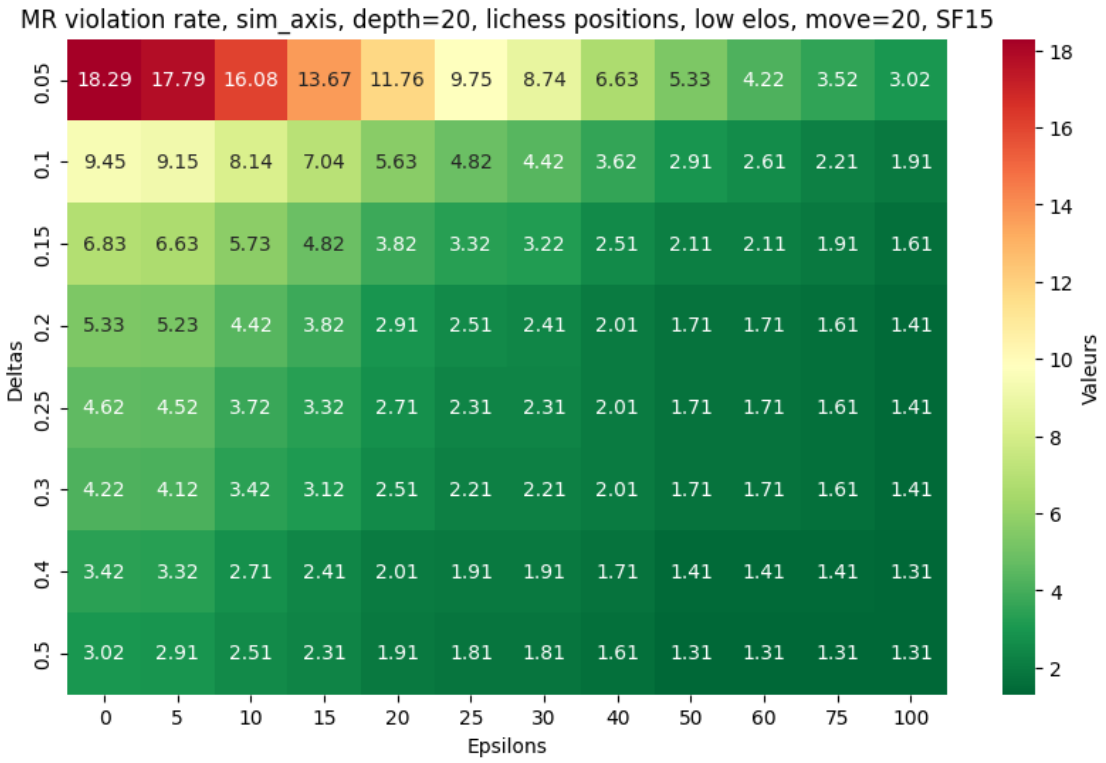



### Middlegames (move=20)

### Lichess positions - 1000 to 1500 elo rating

[584]:
```
path = os.path.join('reals','ev_lichess1000-1500-20sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, low elos, move=20, SF15")
```

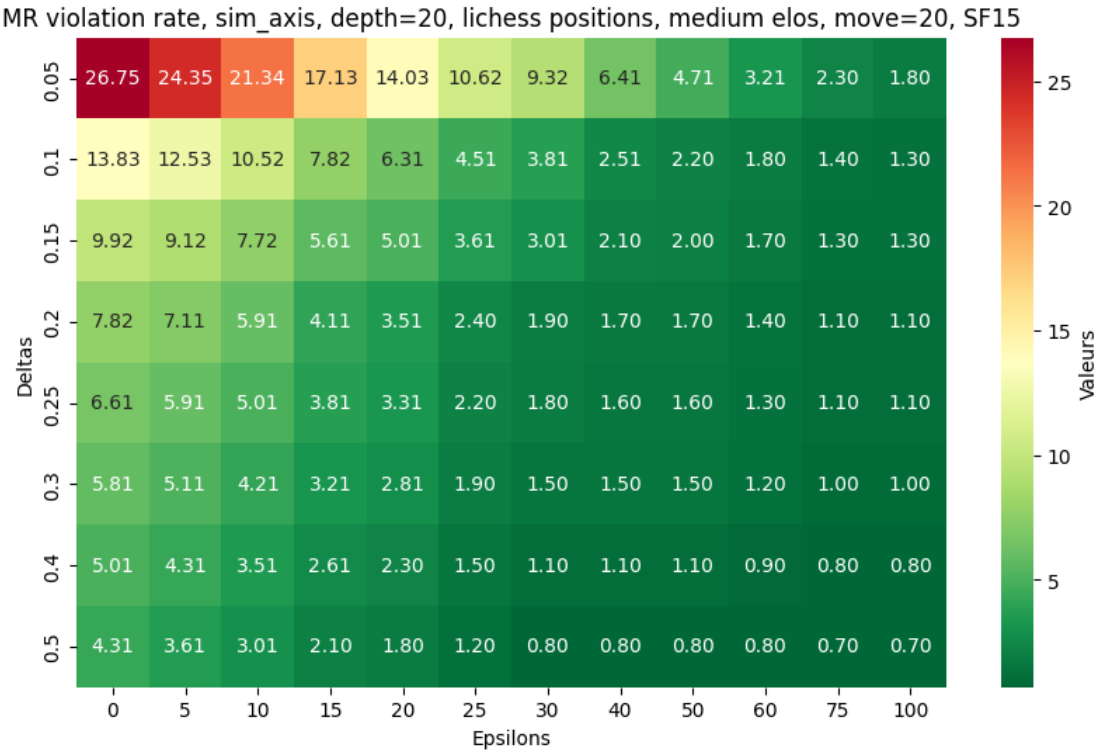
```
move = 20
```




**Lichess positions - 1500 to 2000 elo rating**

[586]:
```
path = os.path.join('reals','ev_lichess1500-2000-20sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, medium elos, move=20, SF15")
```

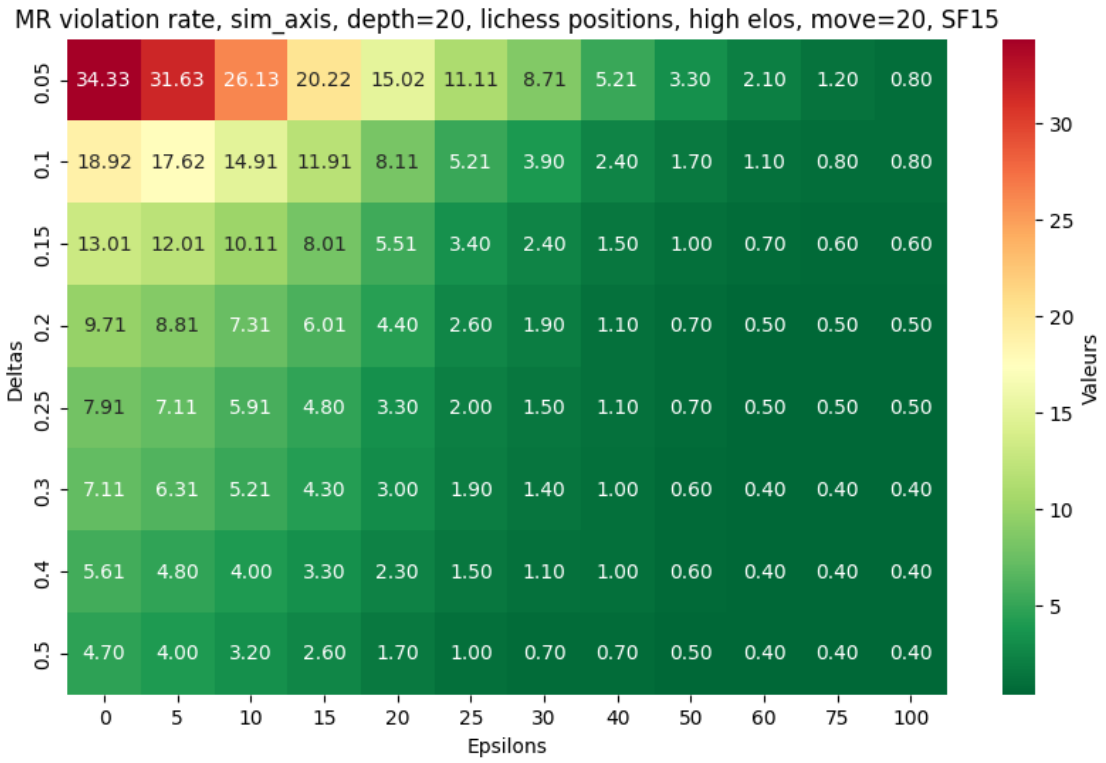
```
move = 20
```




**Lichess positions - 2000 to 2500 elo rating**

[587]:
```
path = os.path.join('reals','ev_lichess2000-2500-20sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, high elos, move=20, SF15")
```

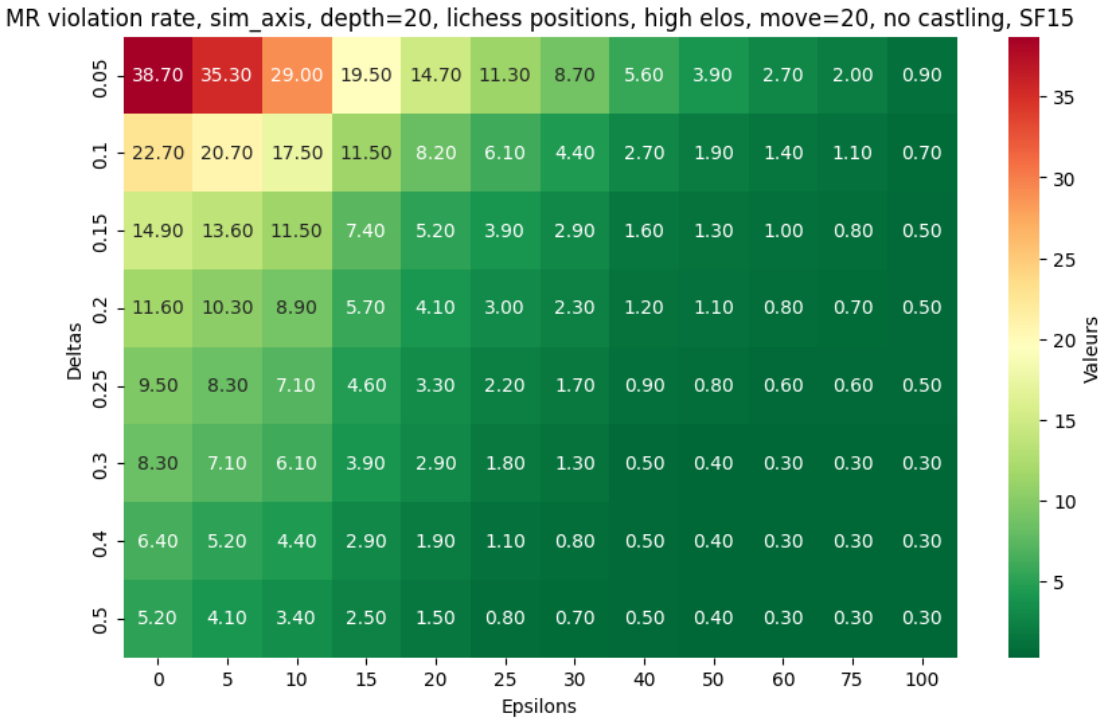
```
move = 20
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[717]:
```
path = os.path.join('reals','ev_lichess2000-2500-20_nocastlingsim_axis_d_20.
  ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, high elos, move=20, no castling, SF15")
```

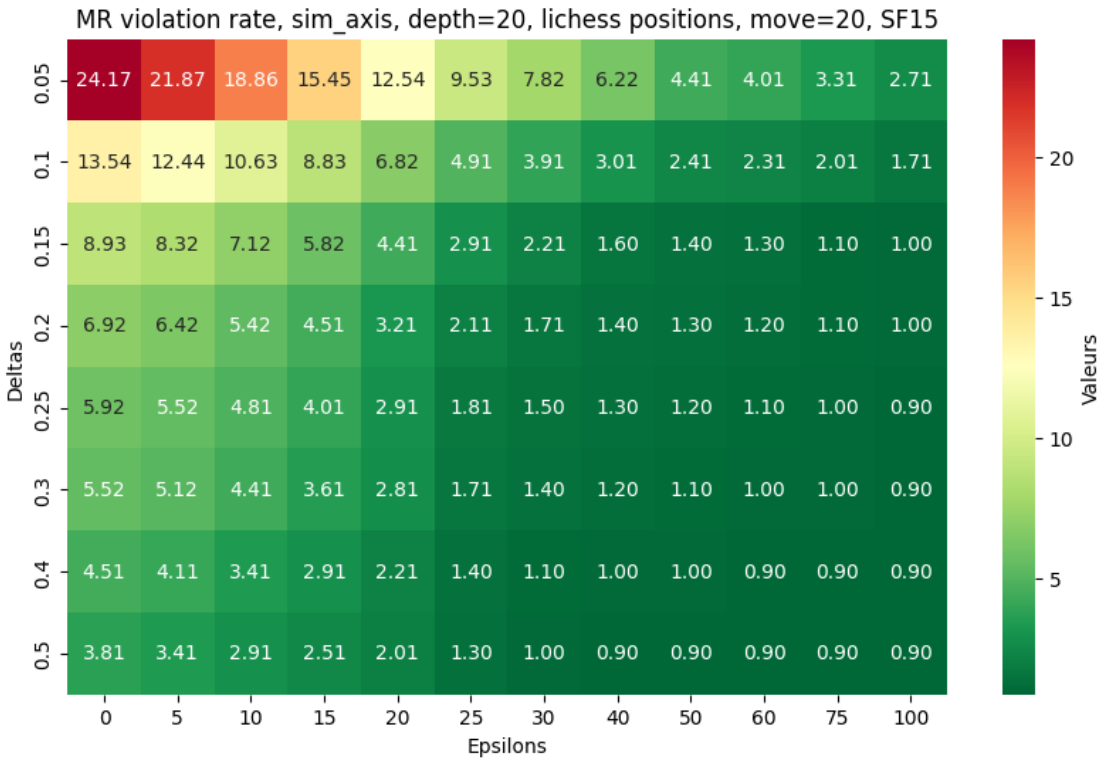
```
move = 20
```




**Lichess positions - All elos**

[589]:
```
path = os.path.join('reals','ev_lichessAllElos-20sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, move=20, SF15")
```

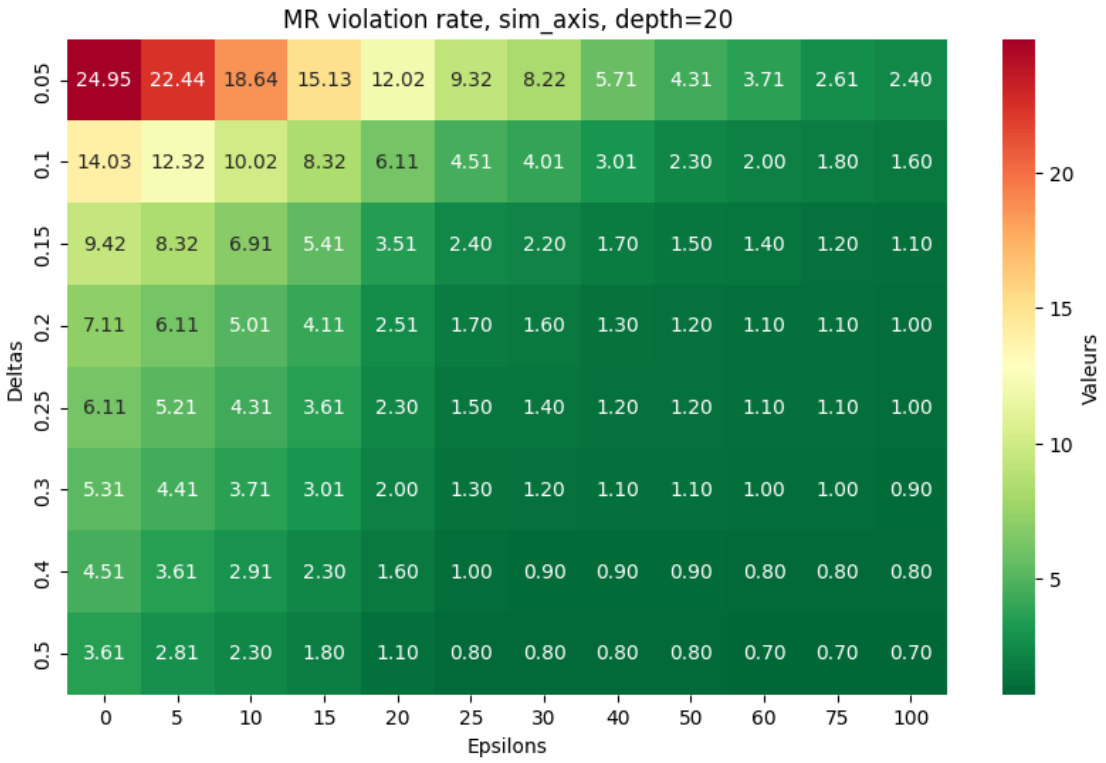
```
move = 20
```




**Lichess positions - All elos, no castling available**

[723]:
```
path = os.path.join('reals','ev_lichessAllElos-20_nocastlingsim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)


print('move = 20')
tests(evs,1,20)
```

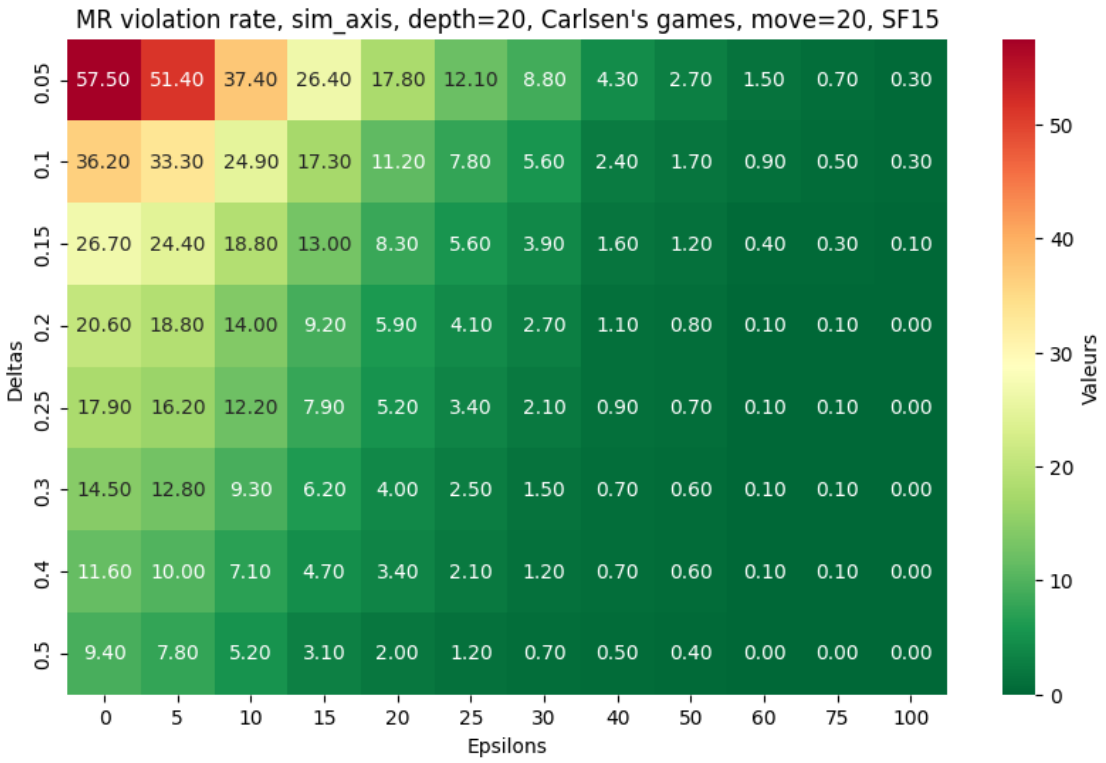
```
move = 20
```




### Carlsen's games

[590]:
```
path = os.path.join('reals','ev_Carlsen-20sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", Carlsen's games, move=20, SF15")
```

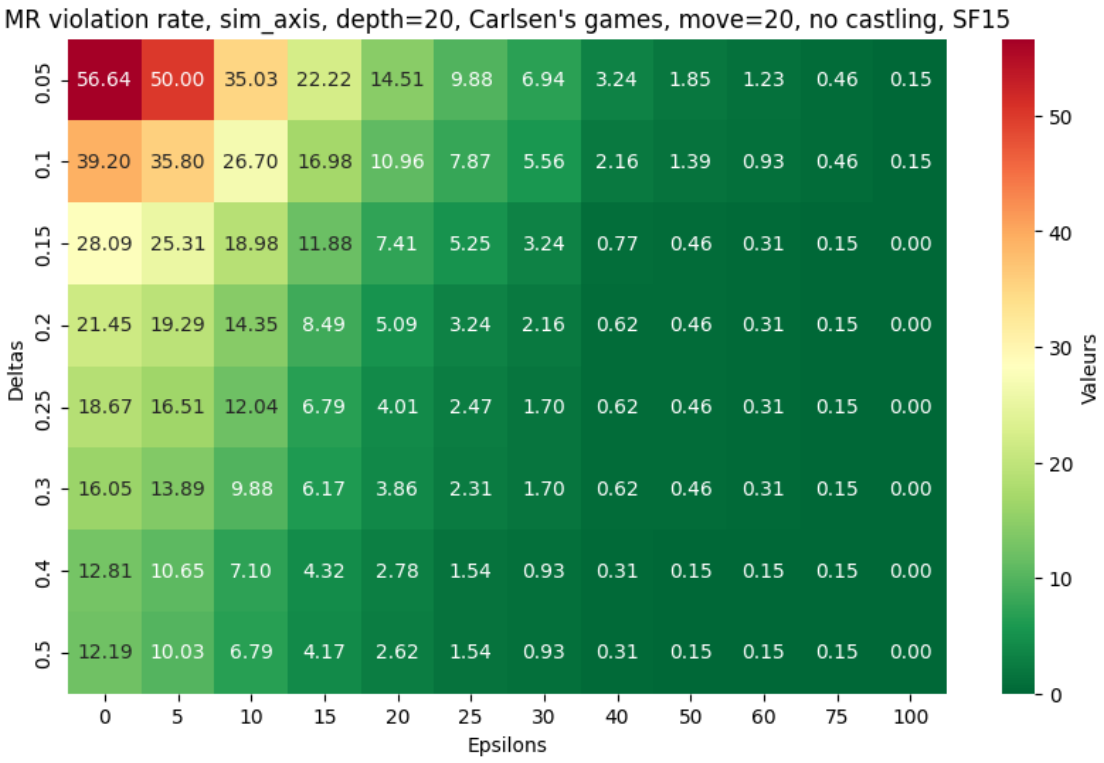
```
move = 20
```




**Carlsen's games, no castling available**

[591]:
```
path = os.path.join('reals','ev_Carlsen-20_nocastlingsim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs11520 = pickle.load(file)

print('move = 20')
tests(evs11520,1,20, ", Carlsen's games, move=20, no castling, SF15")
```

```
move = 20
```

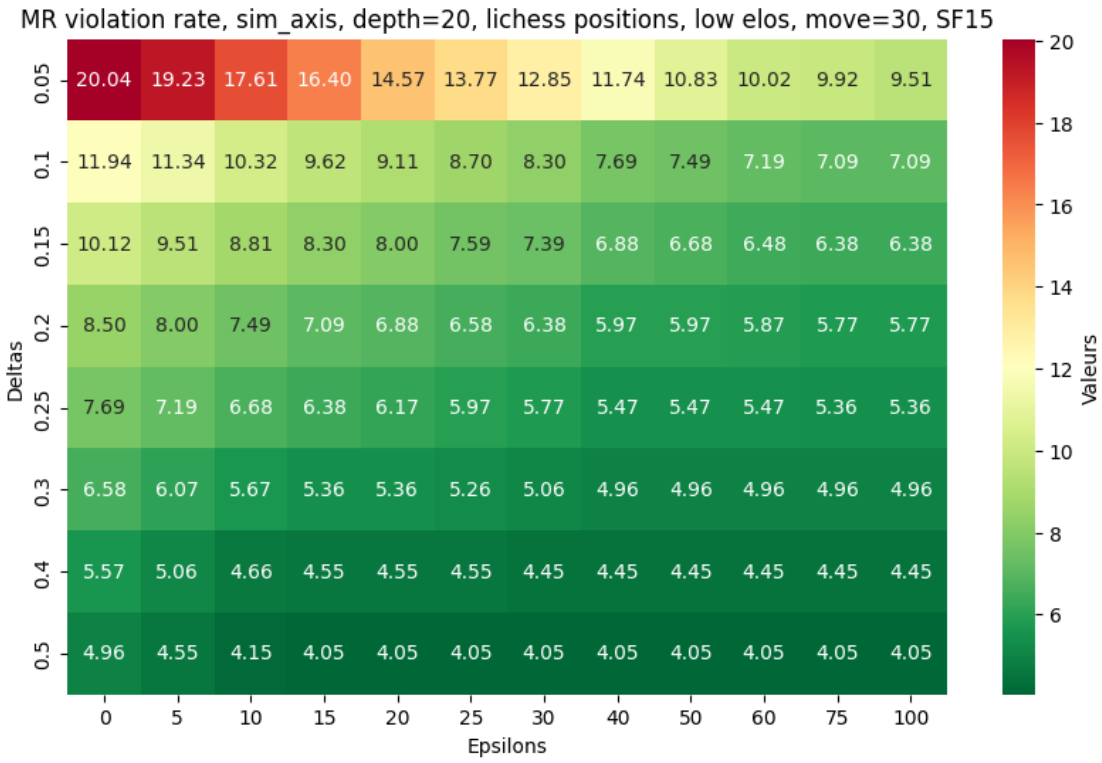



### Middle/Endgames (move=30)

### Lichess positions - 1000 to 1500 elo rating

[592]:
```
path = os.path.join('reals','ev_lichess1000-1500-30sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, low elos, move=30, SF15")
```

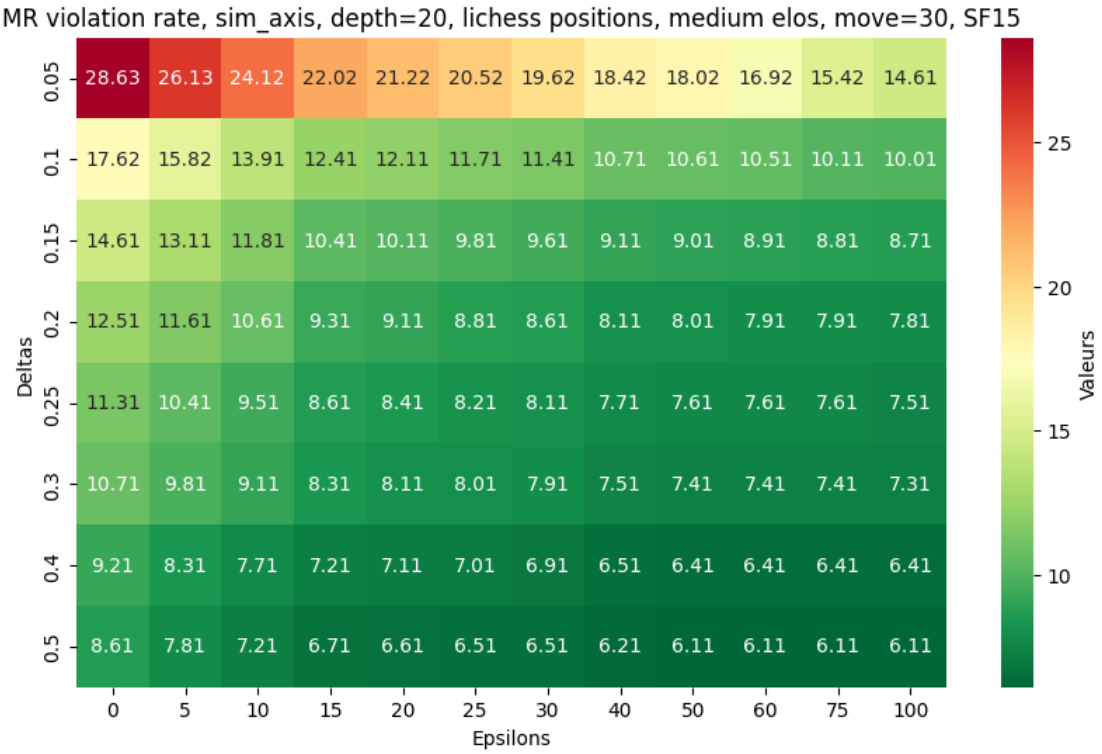
```
move = 30
```




**Lichess positions - 1500 to 2000 elo rating**

[593]:
```
path = os.path.join('reals','ev_lichess1500-2000-30sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, medium elos, move=30, SF15")
```

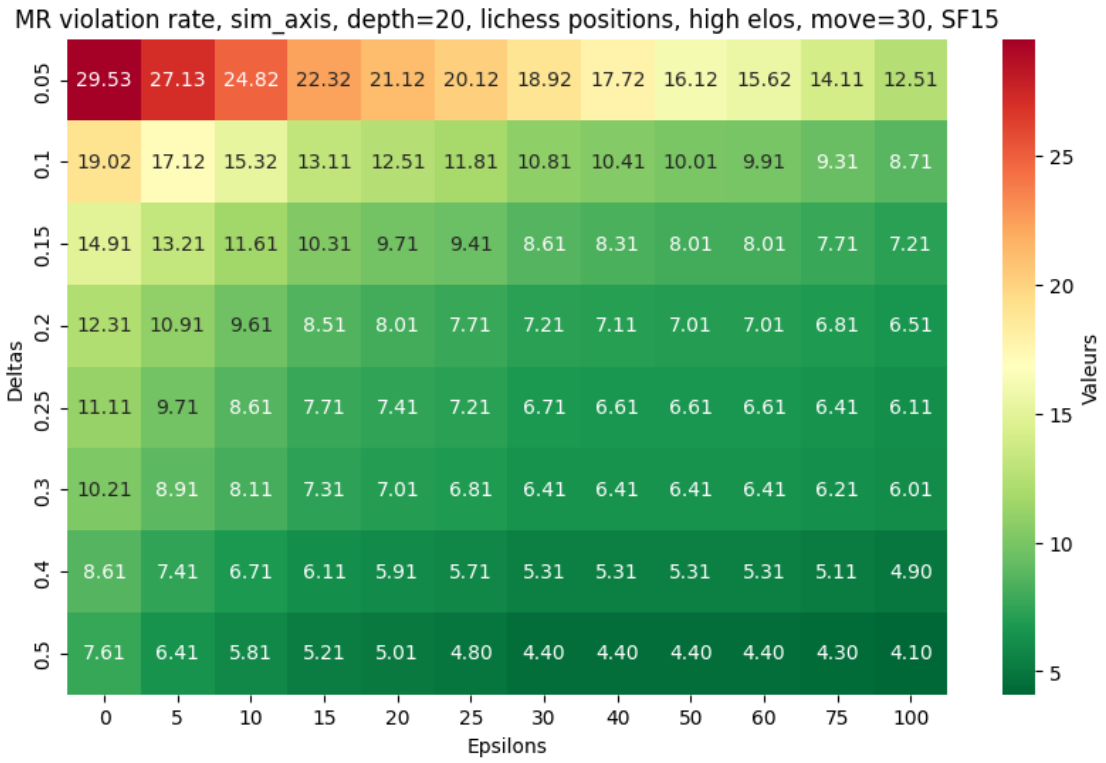
```
move = 30
```




**Lichess positions - 2000 to 2500 elo rating**

[594]:
```
path = os.path.join('reals','ev_lichess2000-2500-30sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, high elos, move=30, SF15")
```

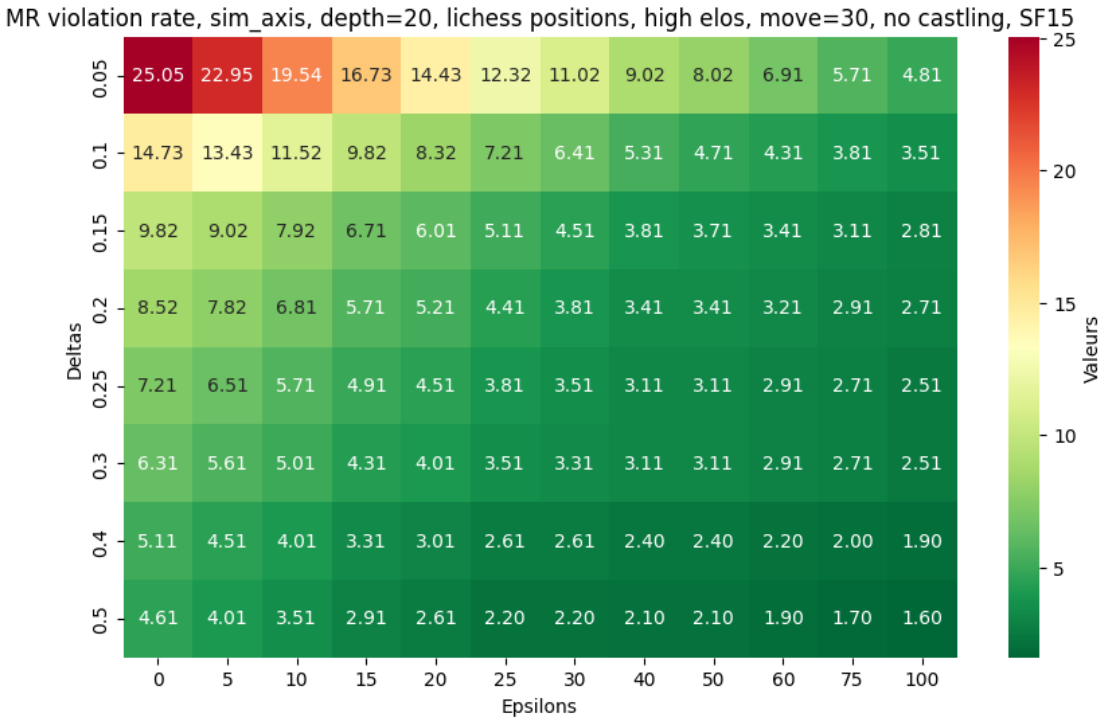
```
move = 30
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[595]:
```
path = os.path.join('reals','ev_lichess2000-2500-30_nocastlingsim_axis_d_20.
  ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, high elos, move=30, no castling, SF15")
```

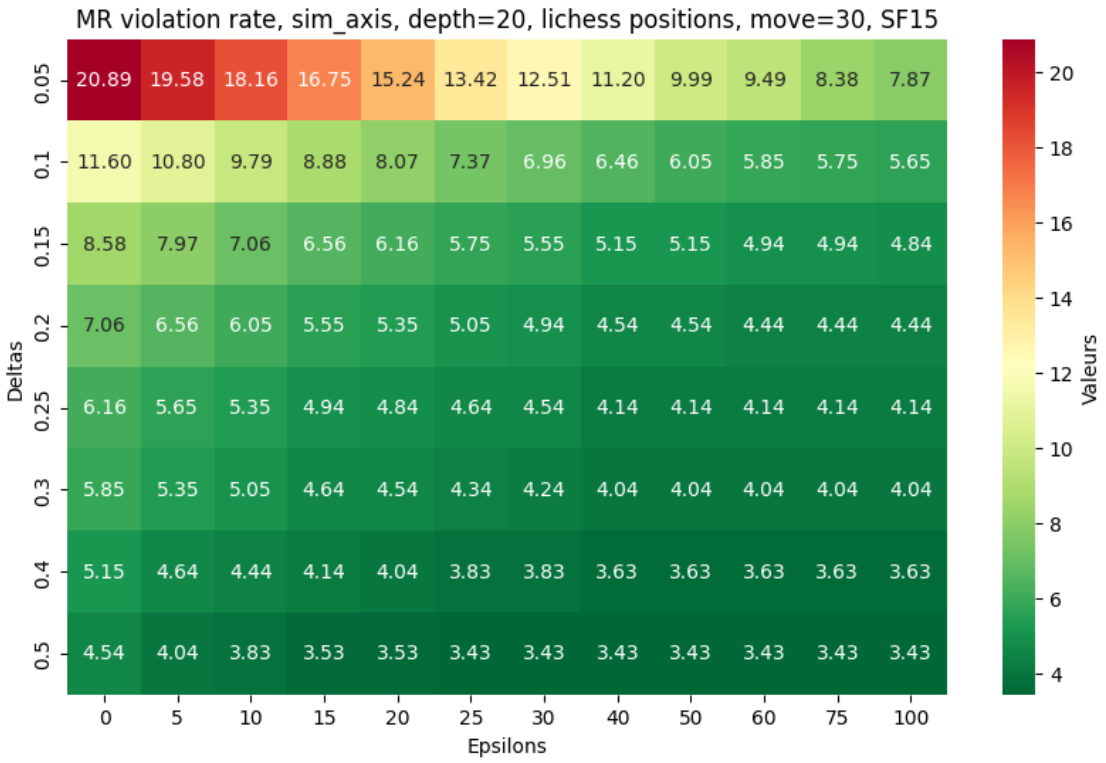
```
move = 30
```




**Lichess positions - All elos**

[596]:
```
path = os.path.join('reals','ev_lichessAllElos-30sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, move=30, SF15")
```

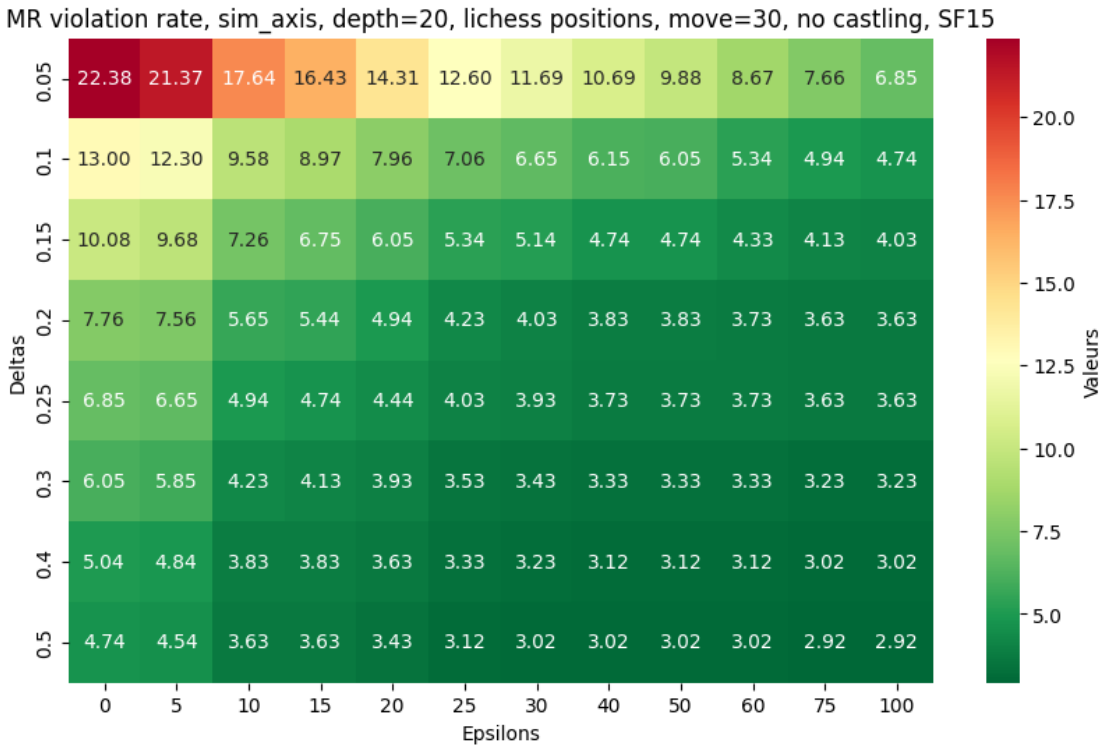
```
move = 30
```




**Lichess positions - All elos, no castling available**

[597]:
```
path = os.path.join('reals','ev_lichessAllElos-30_nocastlingsim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, move=30, no castling, SF15")
```

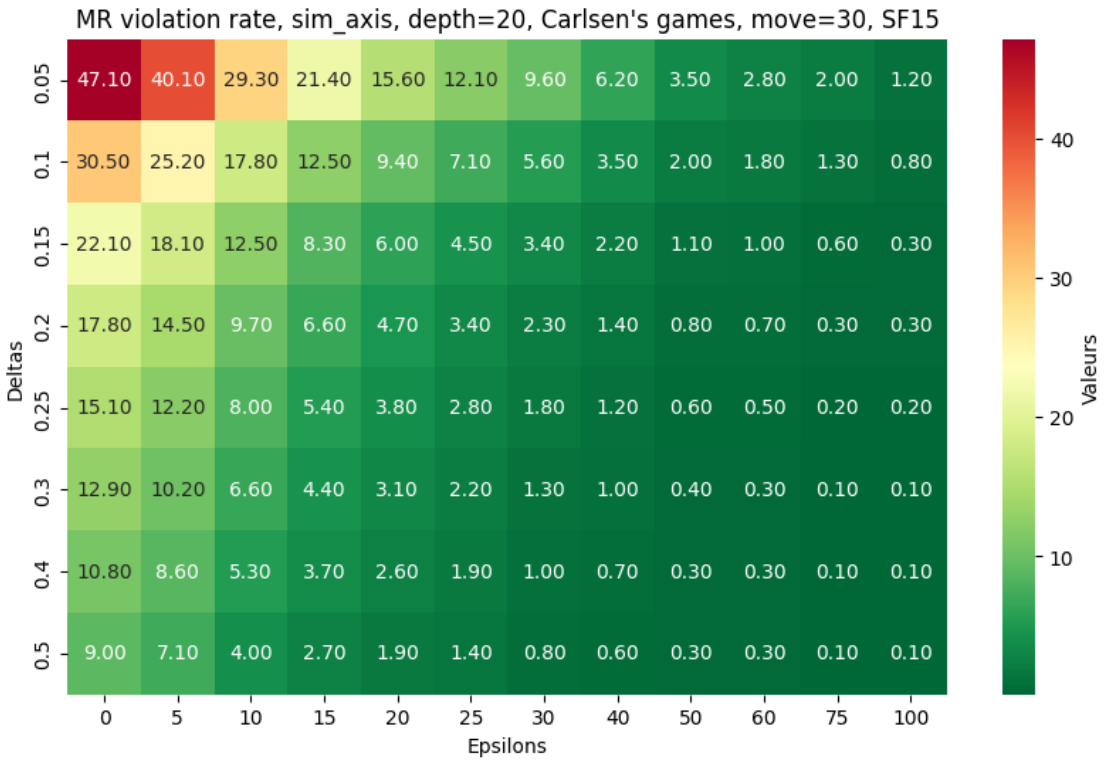
```
move = 30
```




### Carlsen's games

[598]:
```
path = os.path.join('reals','ev_Carlsen-30sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", Carlsen's games, move=30, SF15")
```

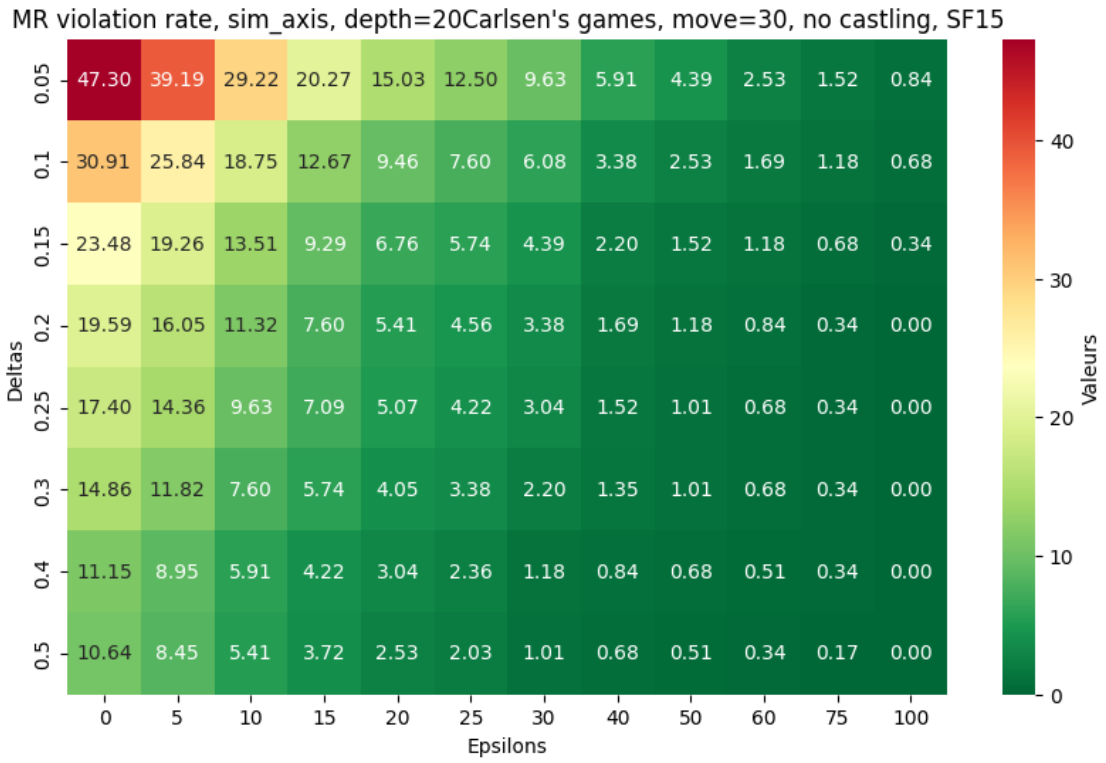
```
move = 30
```




**Carlsen's games, no castling available**

[599]:
```
path = os.path.join('reals','ev_Carlsen-30_nocastlingsim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs11530 = pickle.load(file)

print('move = 30')
tests(evs11530,1,20, "Carlsen's games, move=30, no castling, SF15")
```

```
move = 30
```

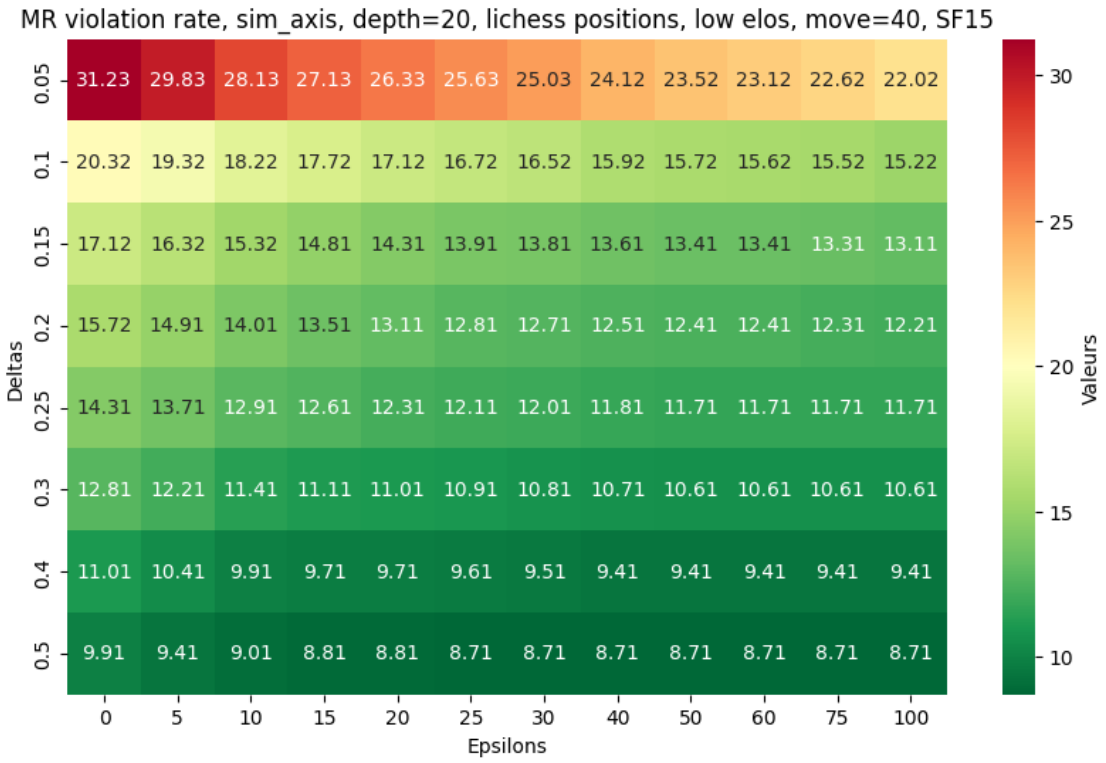



### Endgames (move=40)

### Lichess positions - 1000 to 1500 elo rating

[600]:
```
path = os.path.join('reals','ev_lichess1000-1500-40sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, low elos, move=40, SF15")
```

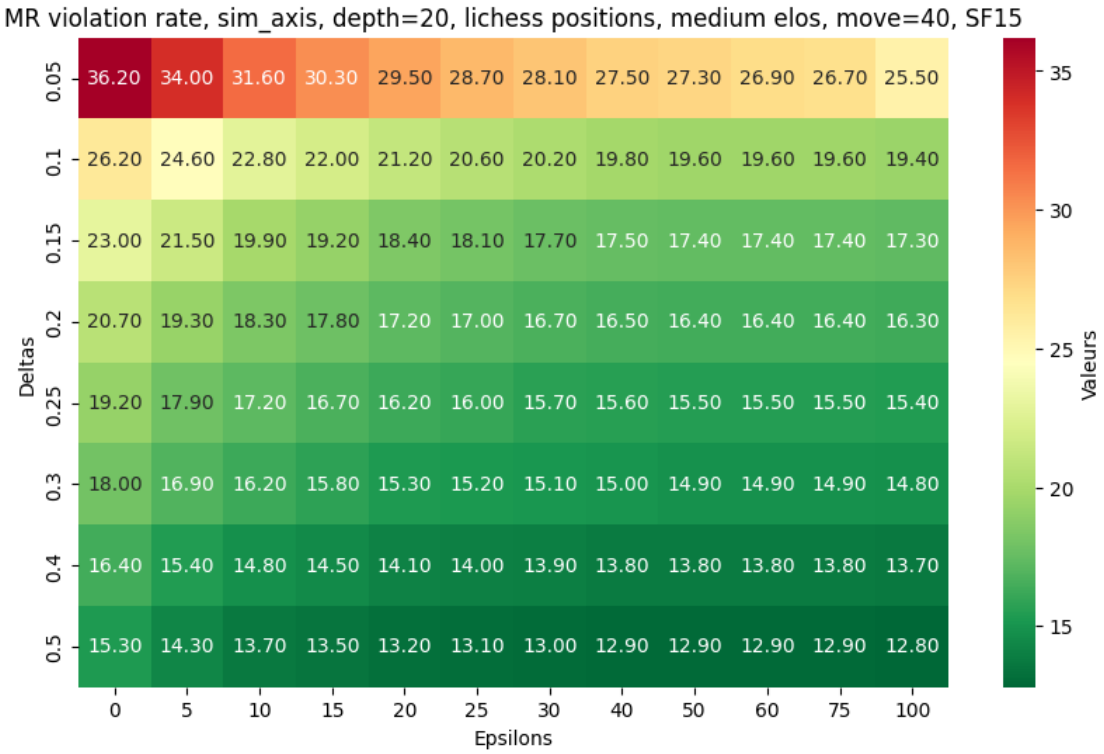
```
move = 40
```




**Lichess positions - 1500 to 2000 elo rating**

[601]:
```
path = os.path.join('reals','ev_lichess1500-2000-40sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, medium elos, move=40, SF15")
```

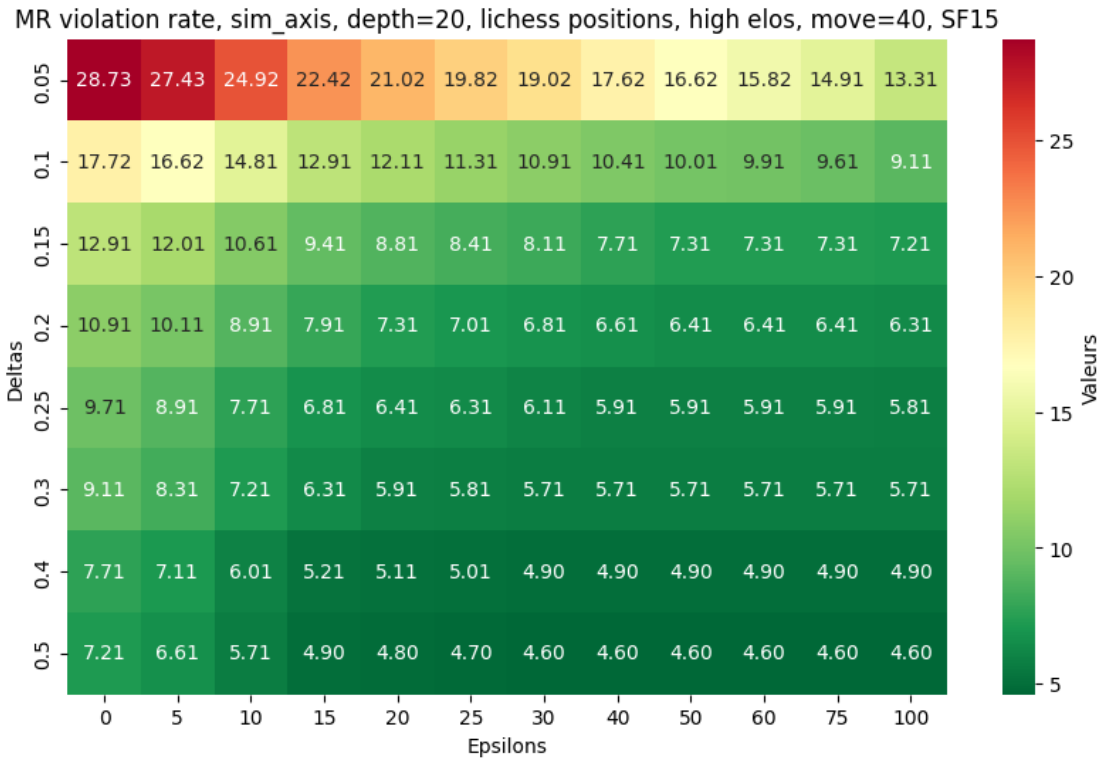
```
move = 40
```




**Lichess positions - 2000 to 2500 elo rating**

[602]:
```
path = os.path.join('reals','ev_lichess2000-2500-40sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, high elos, move=40, SF15")
```

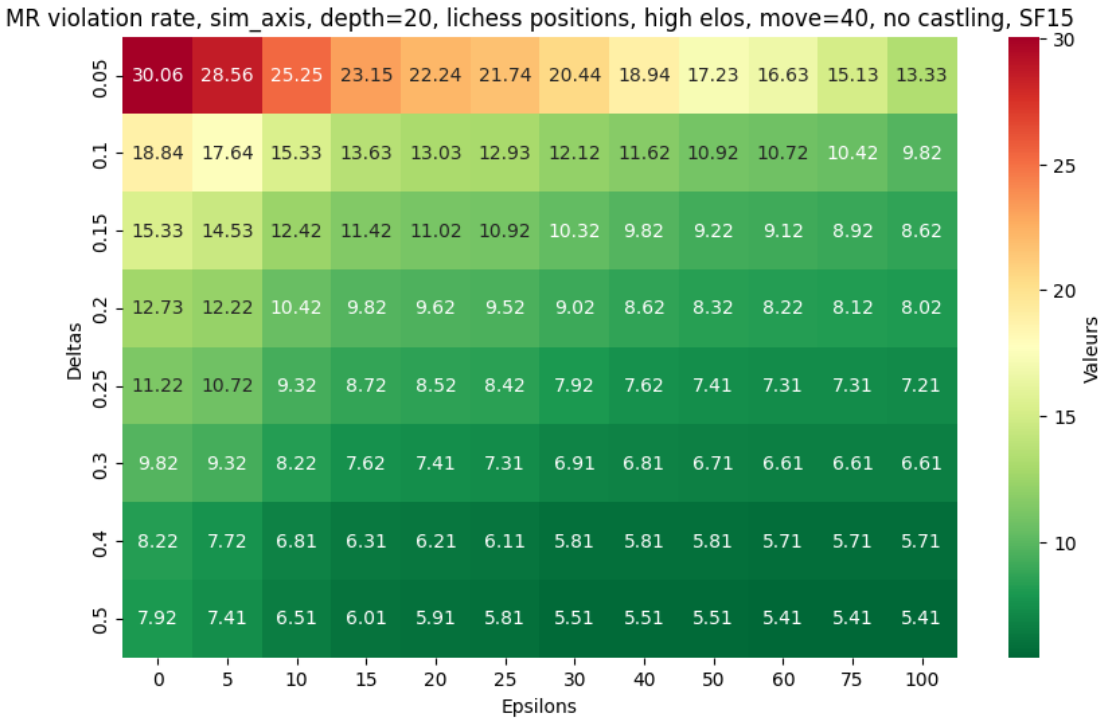
```
move = 40
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[603]:
```
path = os.path.join('reals','ev_lichess2000-2500-40_nocastlingsim_axis_d_20.
 ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, high elos, move=40, no castling, SF15")
```

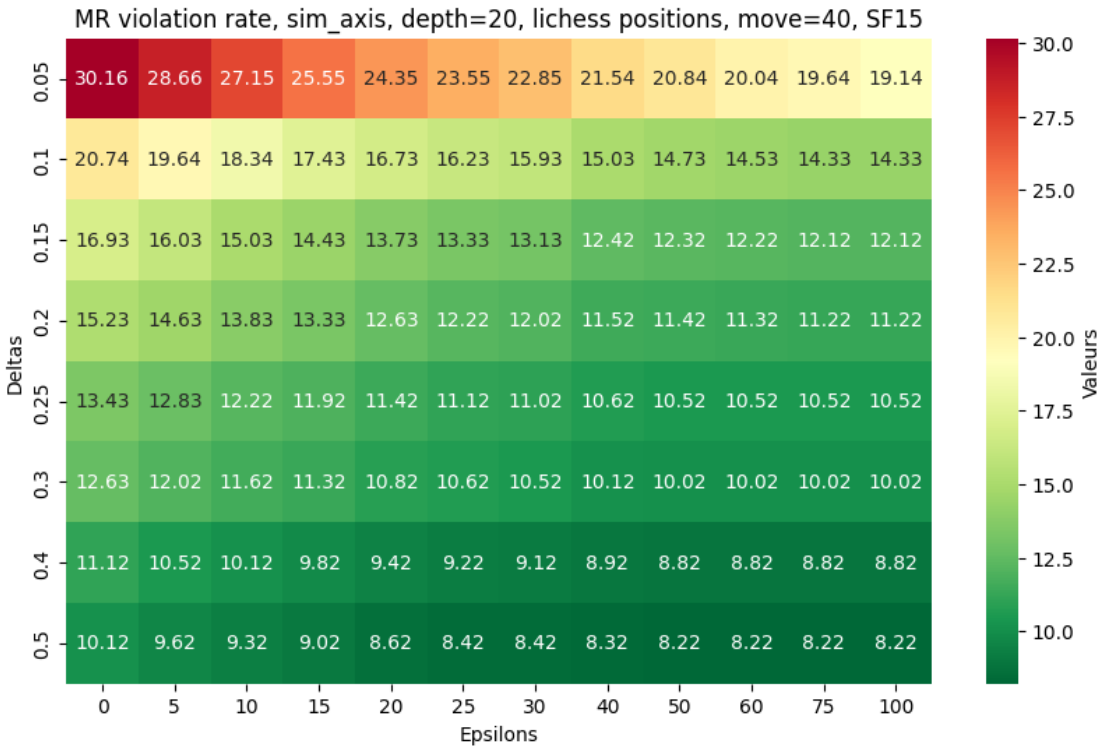
```
move = 40
```




**Lichess positions - All elos**

[604]:
```
path = os.path.join('reals','ev_lichessAllElos-40sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, move=40, SF15")
```

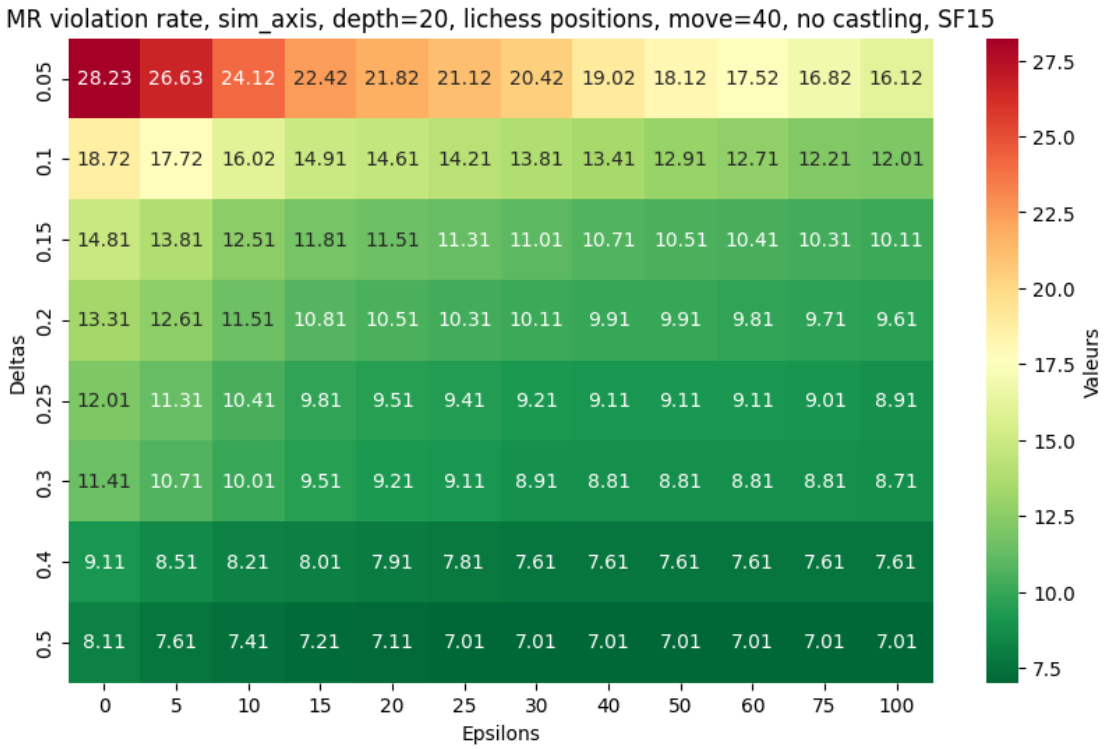
```
move = 40
```




**Lichess positions - All elos, no castling available**

[605]:
```
path = os.path.join('reals','ev_lichessAllElos-40_nocastlingsim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, move=40, no castling, SF15")
```

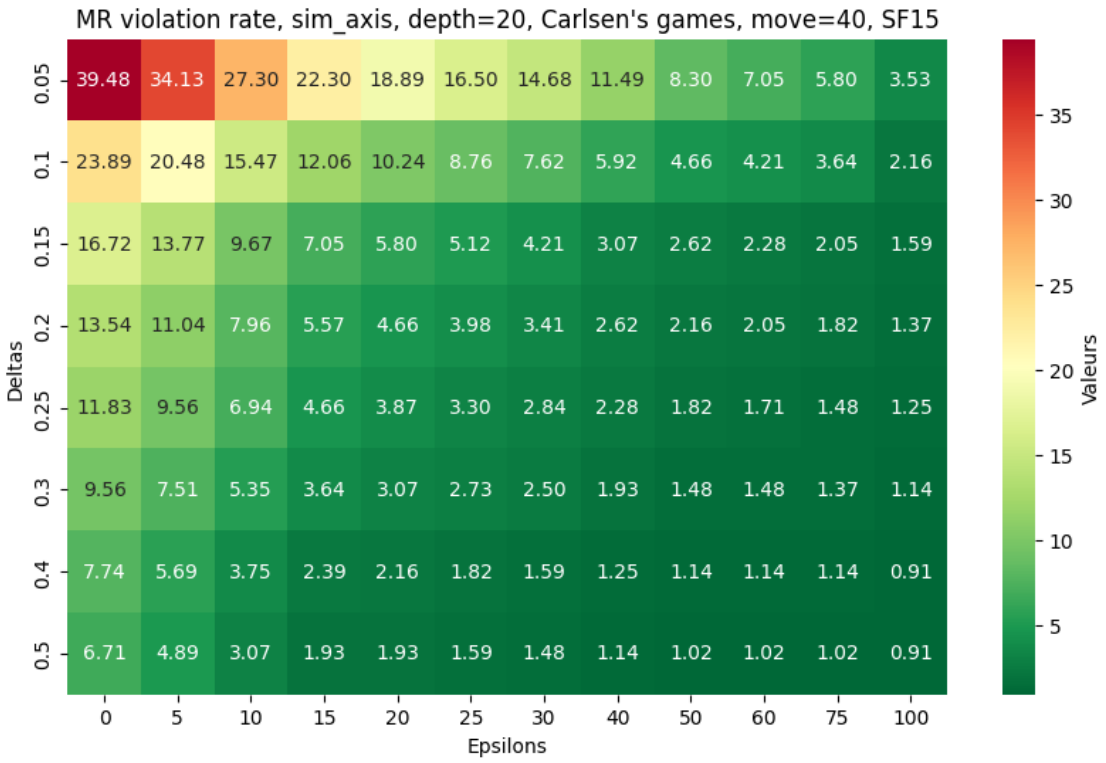
```
move = 40
```




### Carlsen's games

[606]:
```
path = os.path.join('reals','ev_Carlsen-40sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", Carlsen's games, move=40, SF15")
```

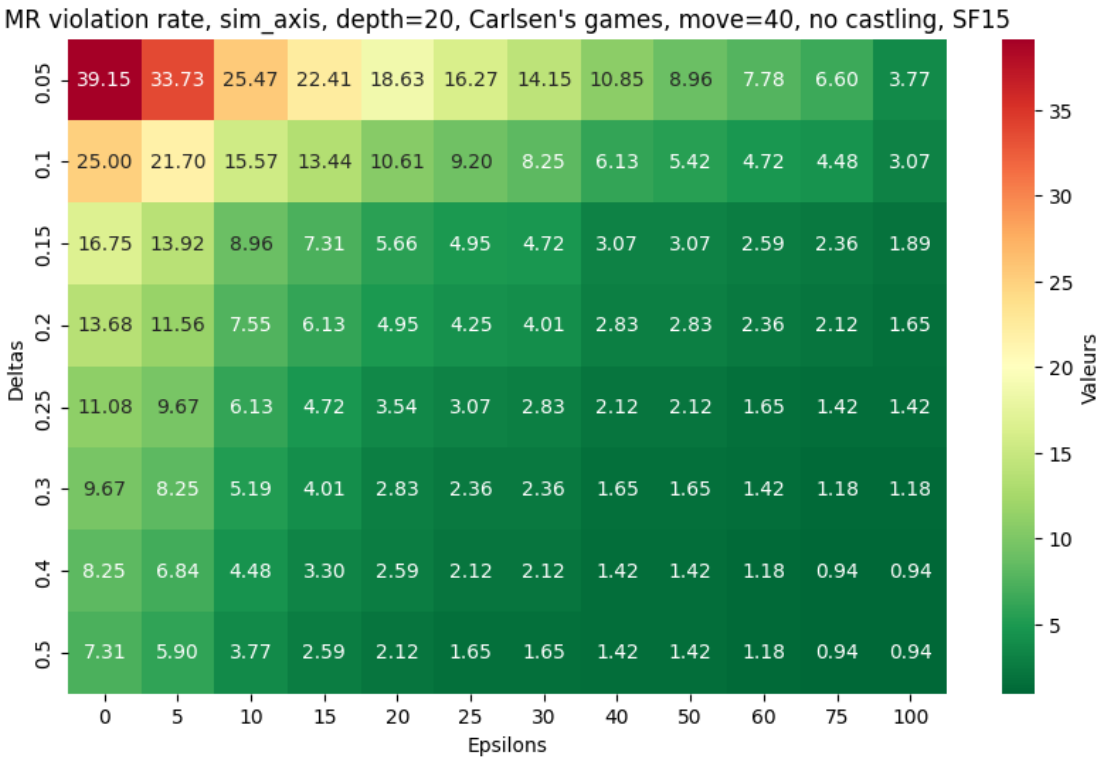
```
move = 40
```




**Carlsen's games, no castling available**

[607]:
```
path = os.path.join('reals','ev_Carlsen-40_nocastlingsim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs11540 = pickle.load(file)

print('move = 40')
tests(evs11540,1,20, ", Carlsen's games, move=40, no castling, SF15")
```

```
move = 40
```




## 0.12 Stockfish 16, lichess

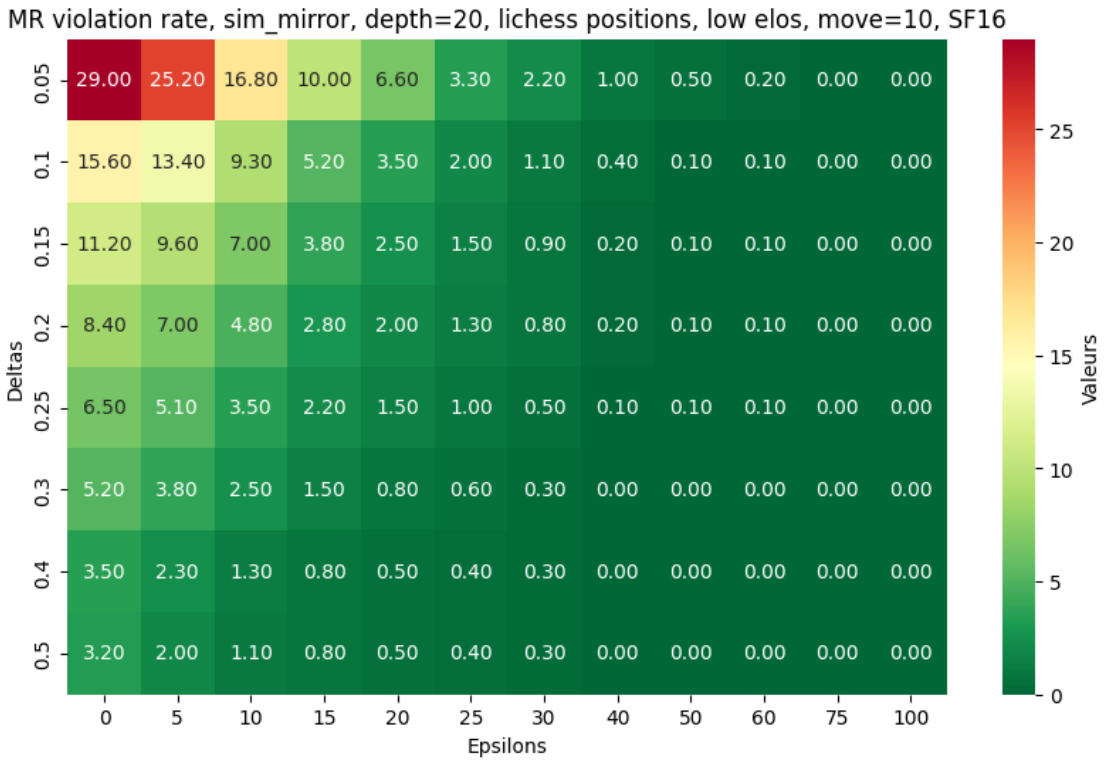
### 0.12.1 sim_mirror

**Openings (move=10)**

**Lichess positions - 1000 to 1500 elo rating**

[608]:
```
path = os.path.join('reals','ev_lichess1000-1500-10sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ", lichess positions, low elos, move=10, SF16")
```

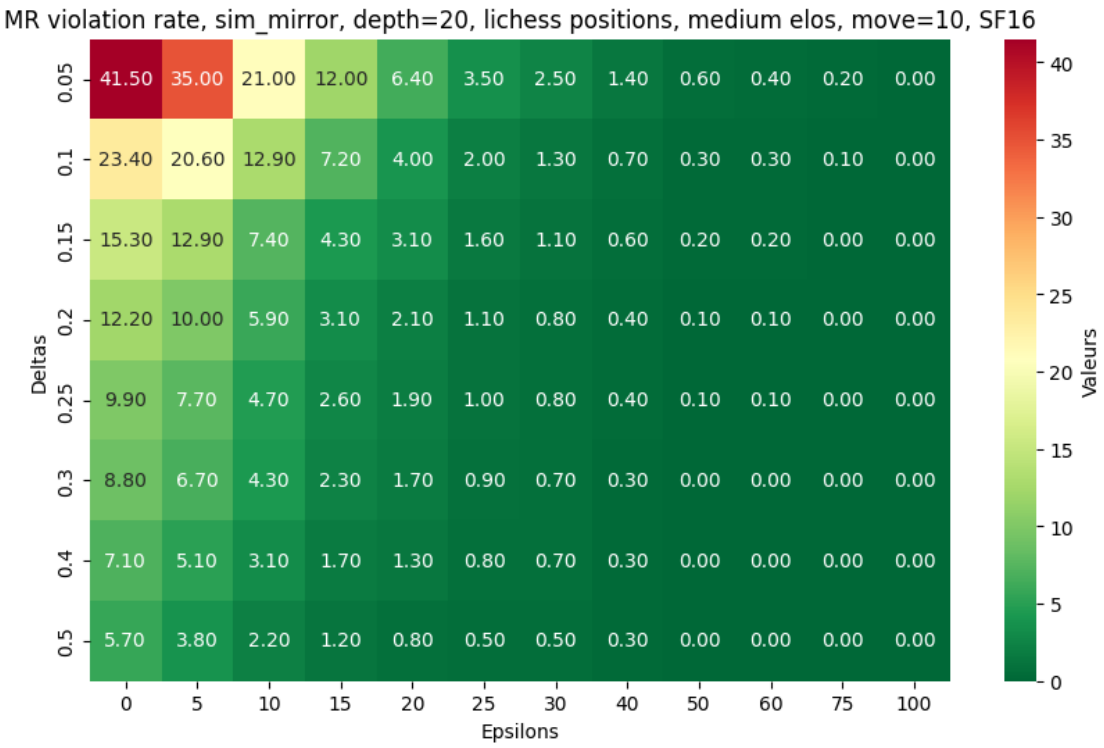
```
move = 10
```




**Lichess positions - 1500 to 2000 elo rating**

[609]:
```
path = os.path.join('reals','ev_lichess1500-2000-10sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ", lichess positions, medium elos, move=10, SF16")
```

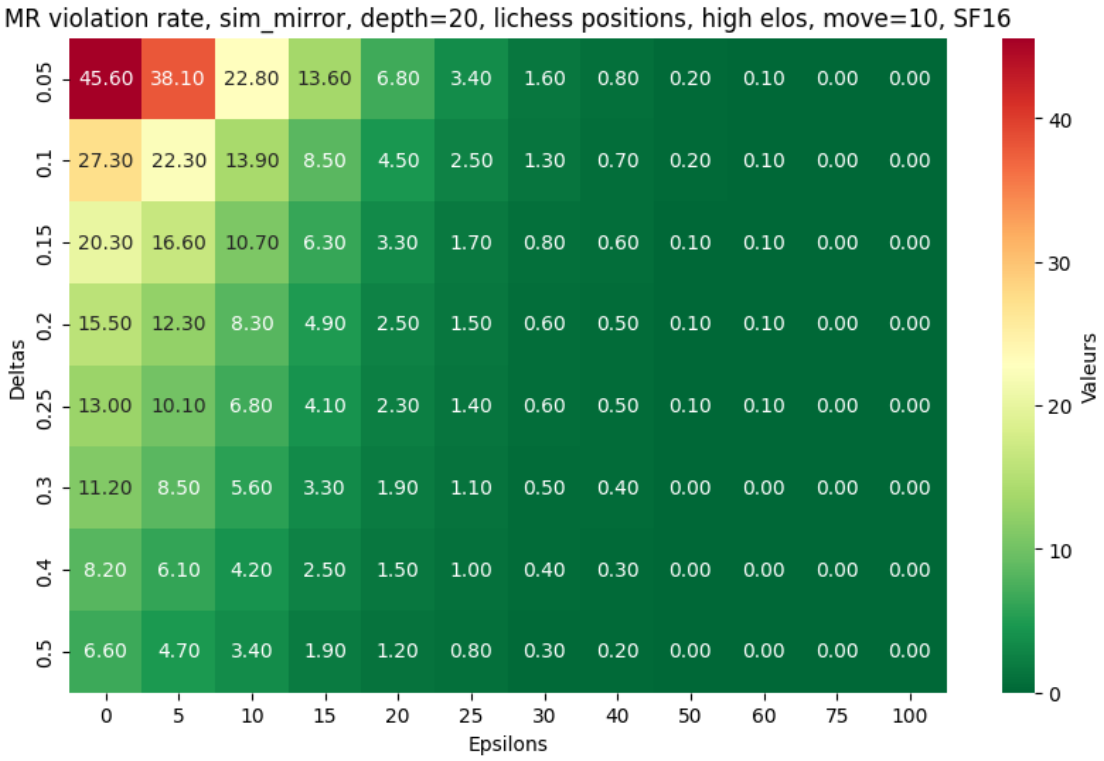
```
move = 10
```




**Lichess positions - 2000 to 2500 elo rating**

[610]:
```
path = os.path.join('reals','ev_lichess2000-2500-10sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ", lichess positions, high elos, move=10, SF16")
```

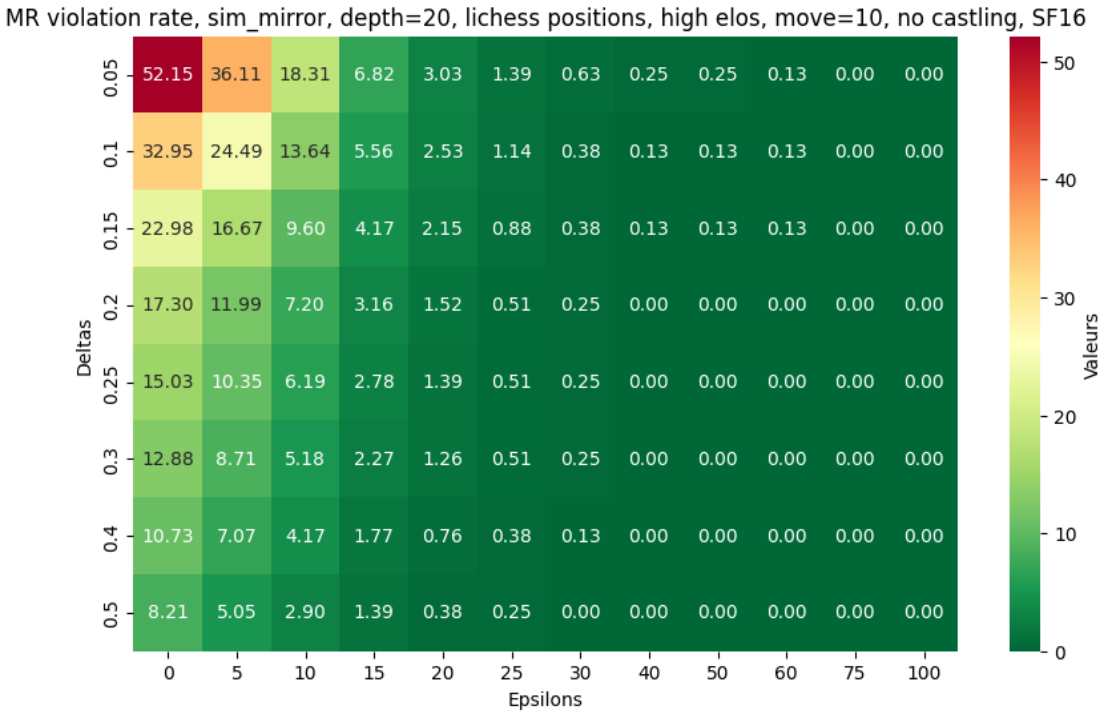
```
move = 10
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[611]:
```
path = os.path.
  ↪join('reals','ev_lichess2000-2500-10_nocastlingsim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ", lichess positions, high elos, move=10, no castling, SF16")
```

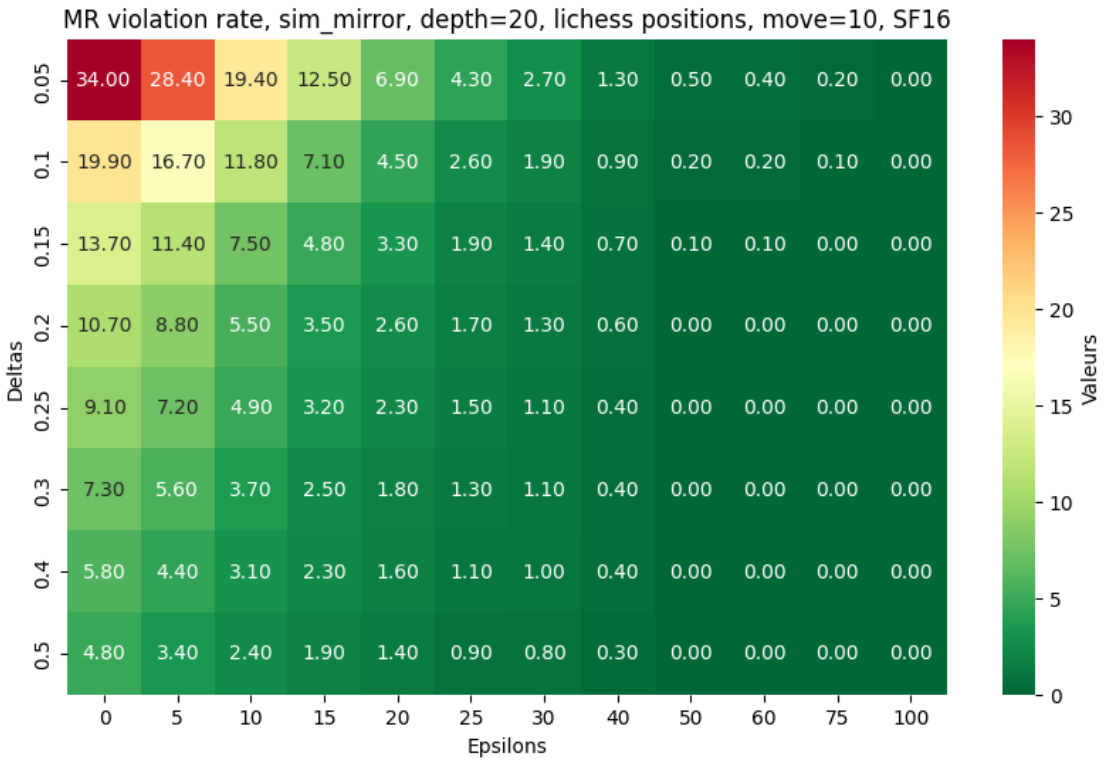
```
move = 10
```




**Lichess positions - All elos**

[612]:
```
path = os.path.join('reals','ev_lichessAllElos-10sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ", lichess positions, move=10, SF16")
```

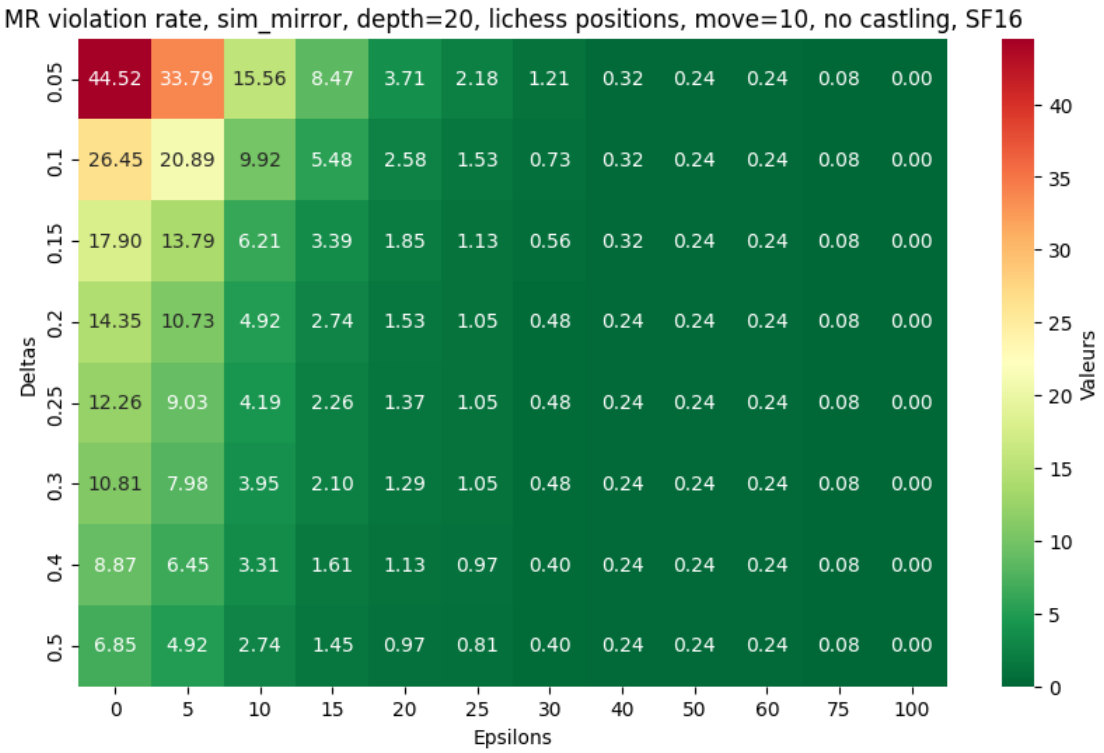
```
move = 10
```




**Lichess positions - All elos, no castling available**

[613]:
```
path = os.path.join('reals','ev_lichessAllElos-10_nocastlingsim_mirror_d_20_v16.
  ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ", lichess positions, move=10, no castling, SF16")
```

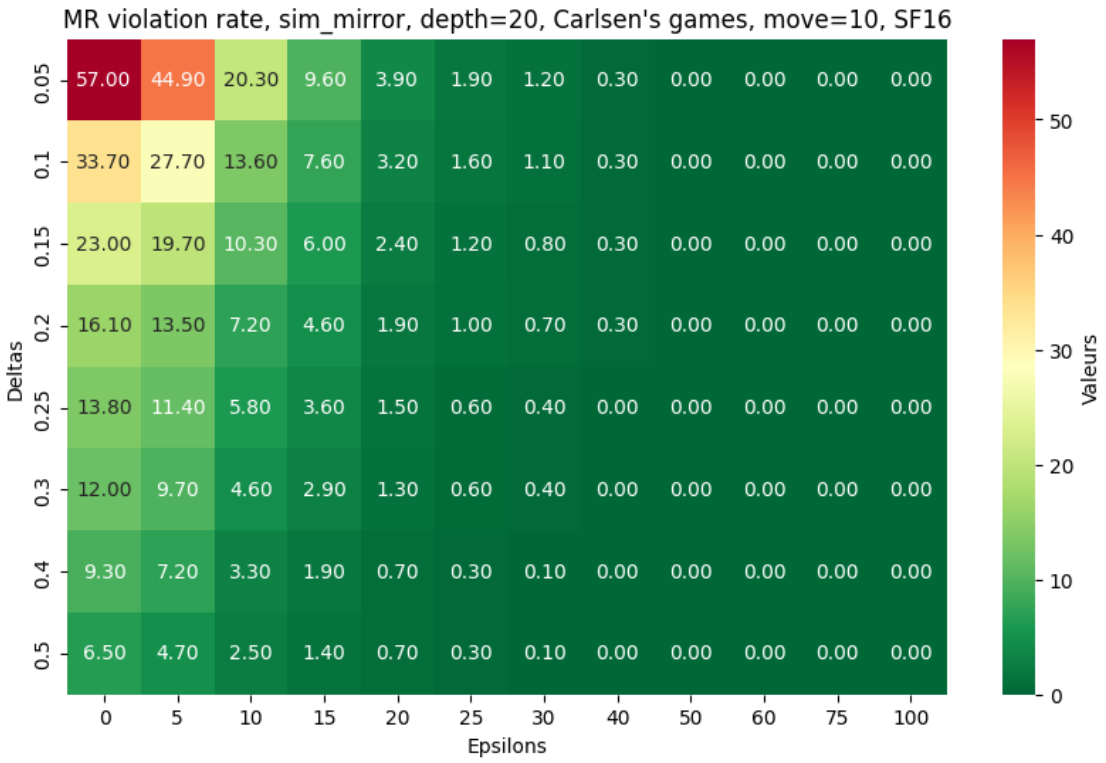
```
move = 10
```




### Carlsen's games

[614]:
```
path = os.path.join('reals','ev_Carlsen-10sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,0,20, ", Carlsen's games, move=10, SF16")
```

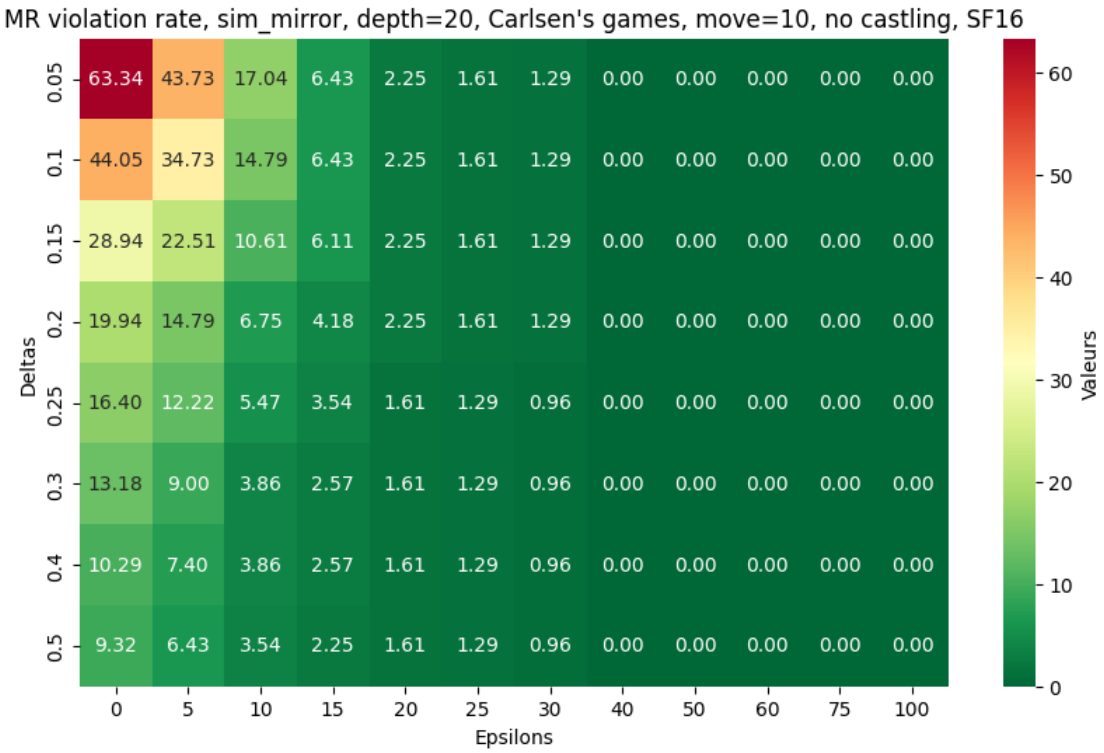
```
move = 10
```




**Carlsen's games, no castling available**

[615]:
```
path = os.path.join('reals','ev_Carlsen-10_nocastlingsim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs01610 = pickle.load(file)

print('move = 10')
tests(evs01610,0,20, ", Carlsen's games, move=10, no castling, SF16")
```

```
move = 10
```

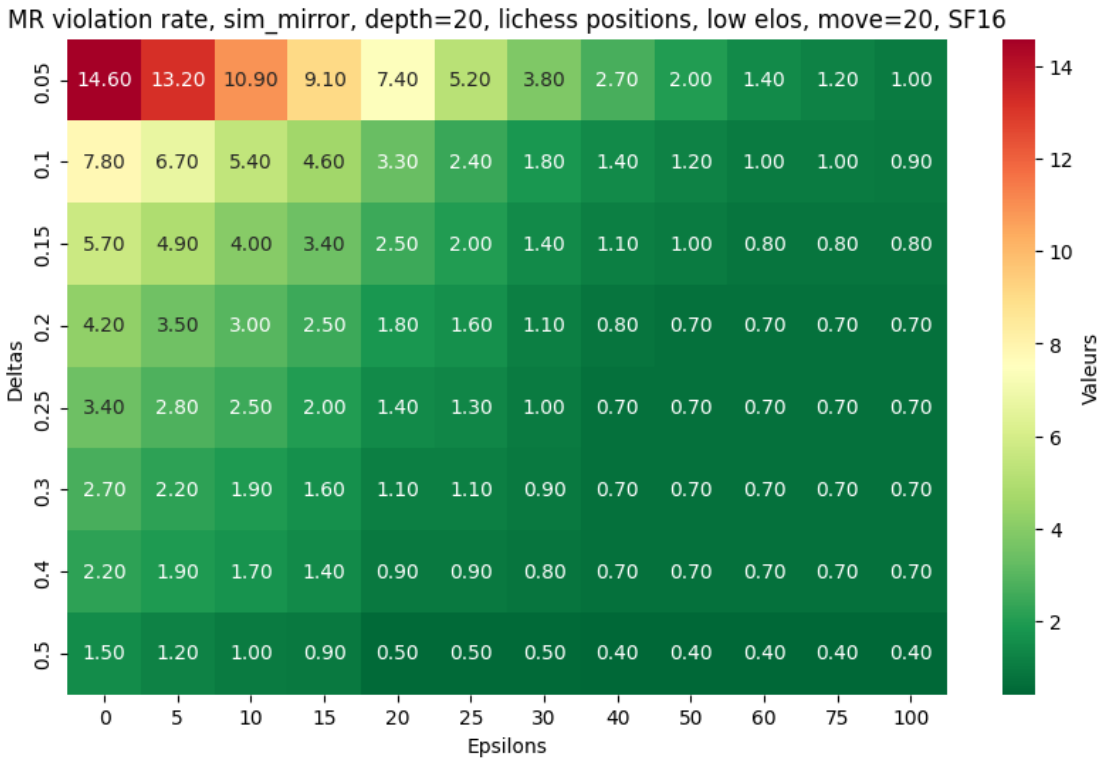



### Middlegames (move=20)

### Lichess positions - 1000 to 1500 elo rating

[619]:
```
path = os.path.join('reals','ev_lichess1000-1500-20sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ", lichess positions, low elos, move=20, SF16")
```

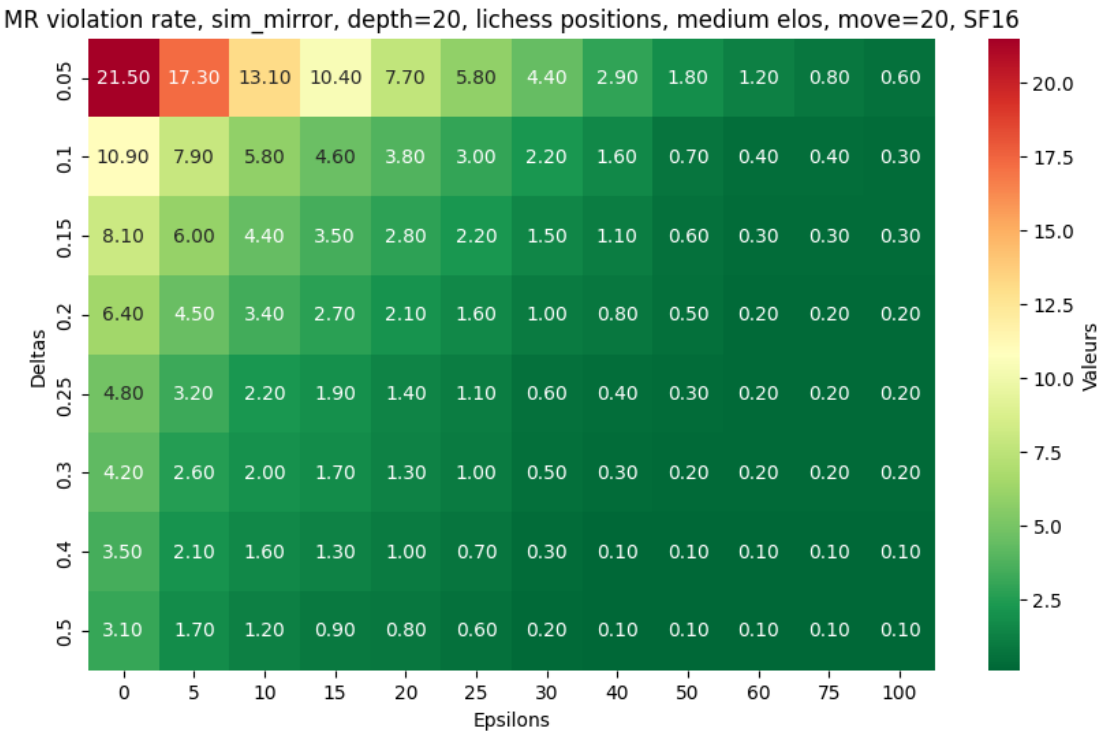
```
move = 20
```




**Lichess positions - 1500 to 2000 elo rating**

[620]:
```
path = os.path.join('reals','ev_lichess1500-2000-20sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ", lichess positions, medium elos, move=20, SF16")
```

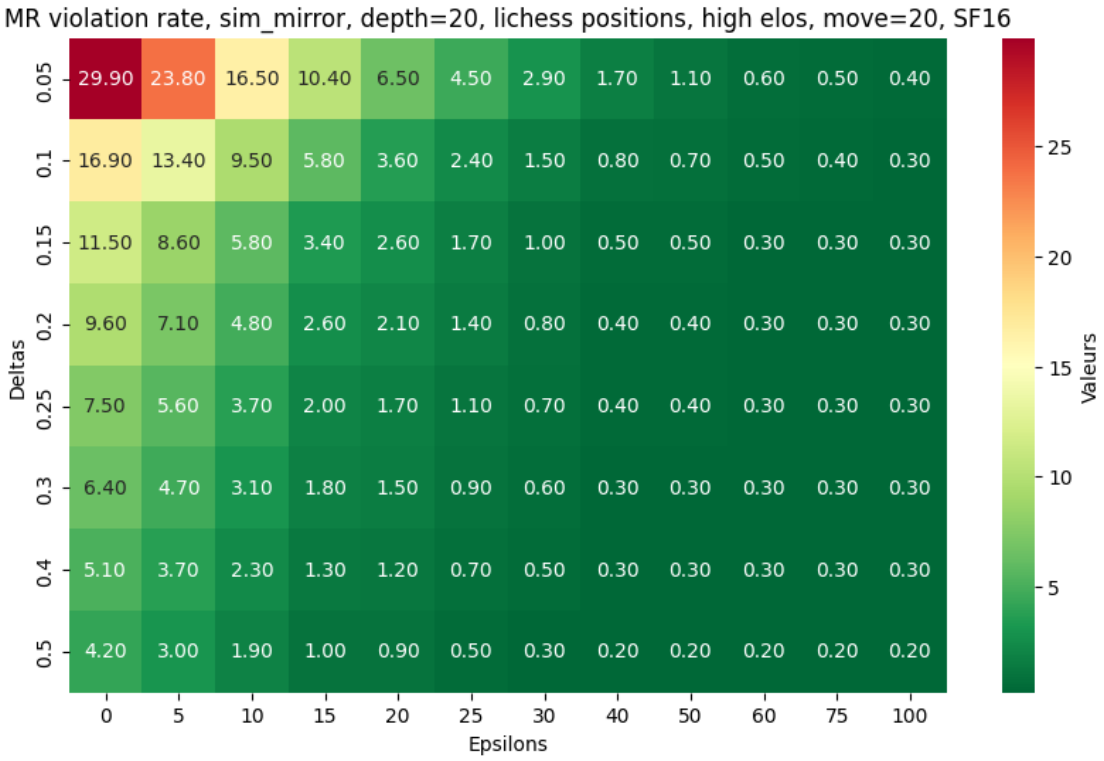
```
move = 20
```




**Lichess positions - 2000 to 2500 elo rating**

[621]:
```
path = os.path.join('reals','ev_lichess2000-2500-20sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ", lichess positions, high elos, move=20, SF16")
```

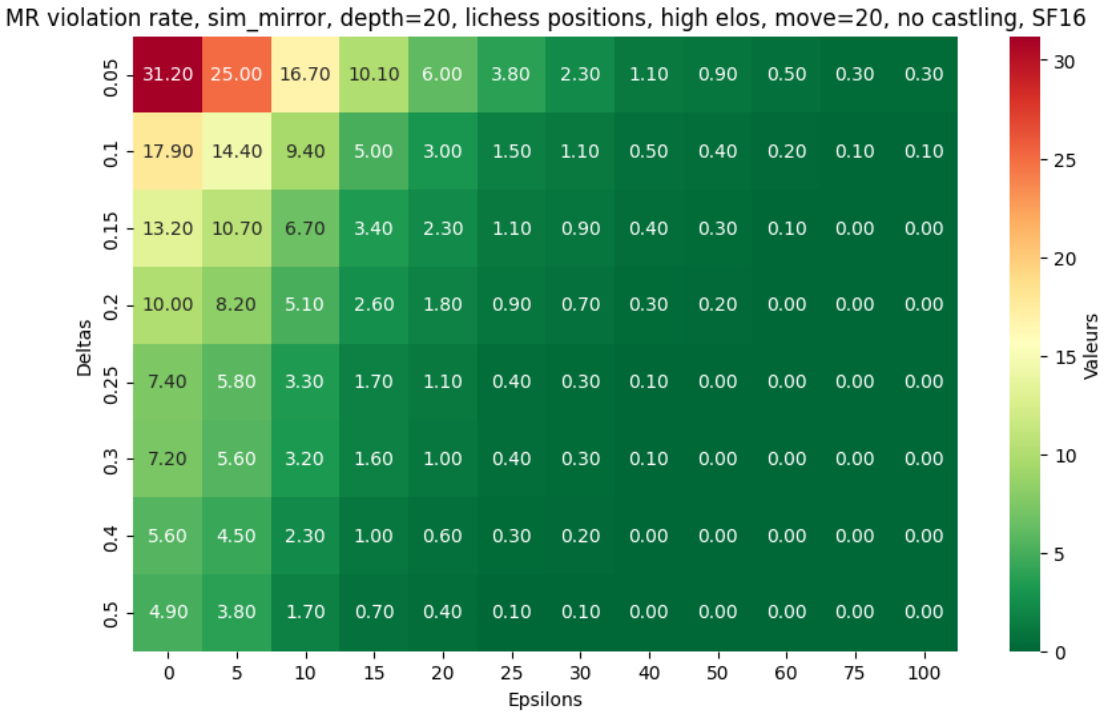
```
move = 20
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[622]:
```
path = os.path.
  ↪join('reals','ev_lichess2000-2500-20_nocastlingsim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ", lichess positions, high elos, move=20, no castling, SF16")
```

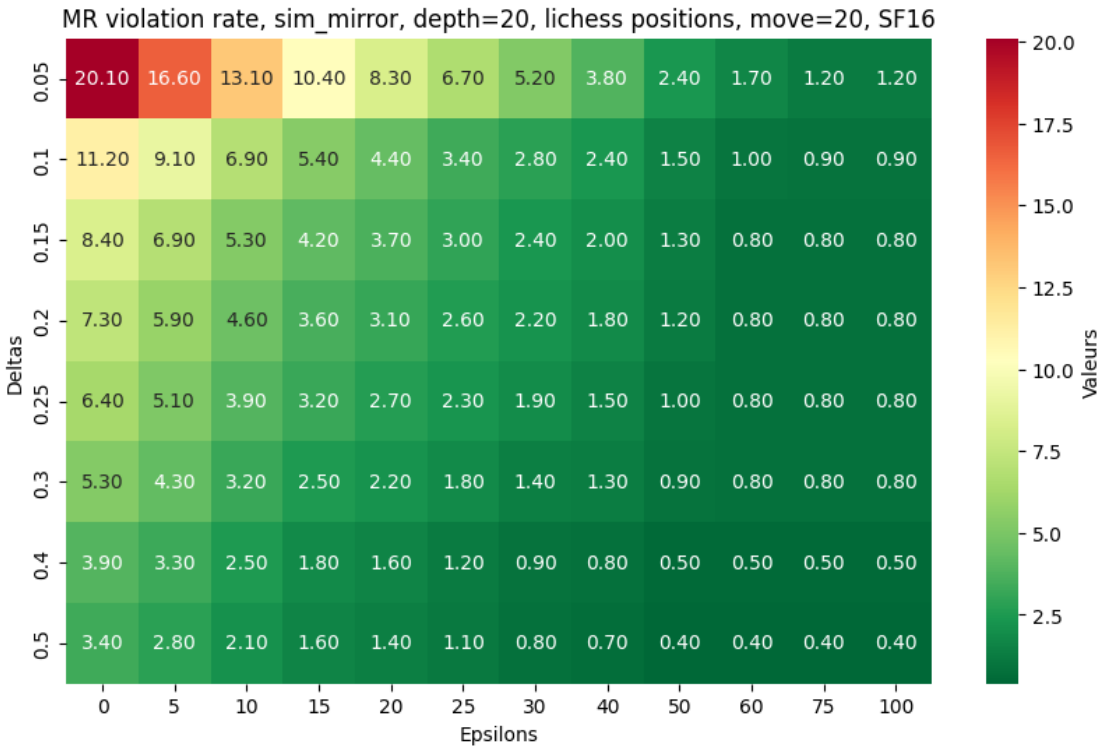
```
move = 20
```




### Lichess positions - All elos

[623]:
```
path = os.path.join('reals','ev_lichessAllElos-20sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ", lichess positions, move=20, SF16")
```

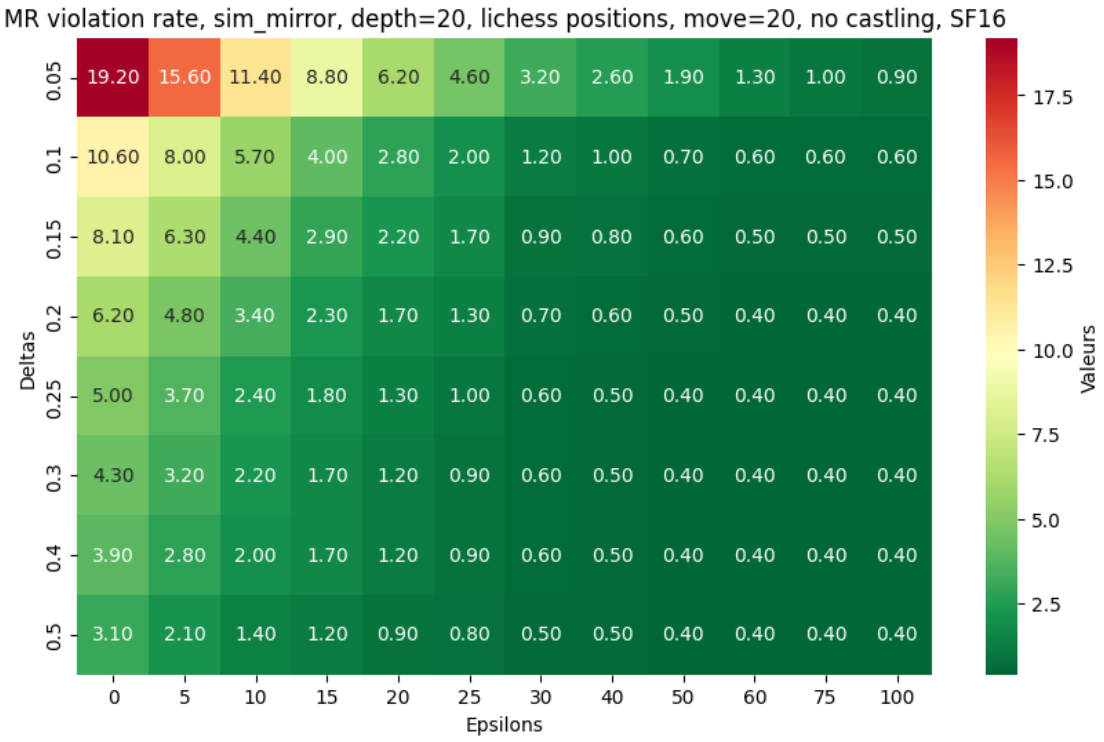
```
move = 20
```




**Lichess positions - All elos, no castling available**

[624]:
```
path = os.path.join('reals','ev_lichessAllElos-20_nocastlingsim_mirror_d_20_v16.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ", lichess positions, move=20, no castling, SF16")
```

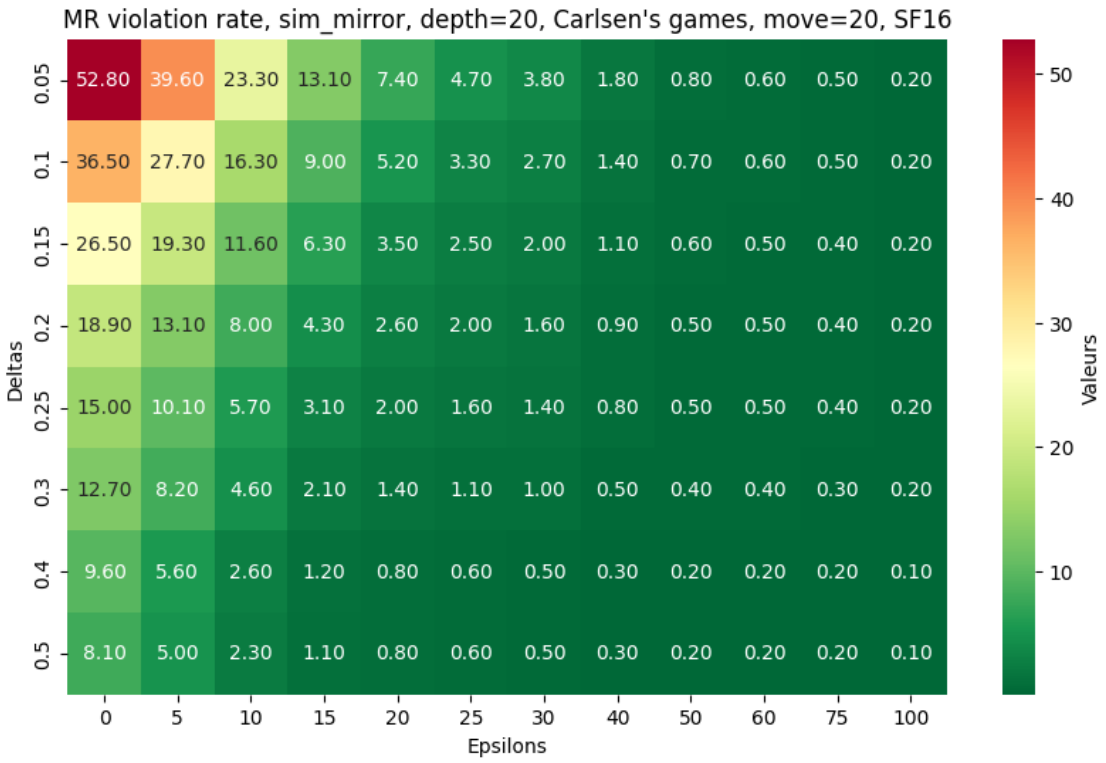
```
move = 20
```




### Carlsen's games

[626]:
```
path = os.path.join('reals','ev_Carlsen-20sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,0,20, ", Carlsen's games, move=20, SF16")
```

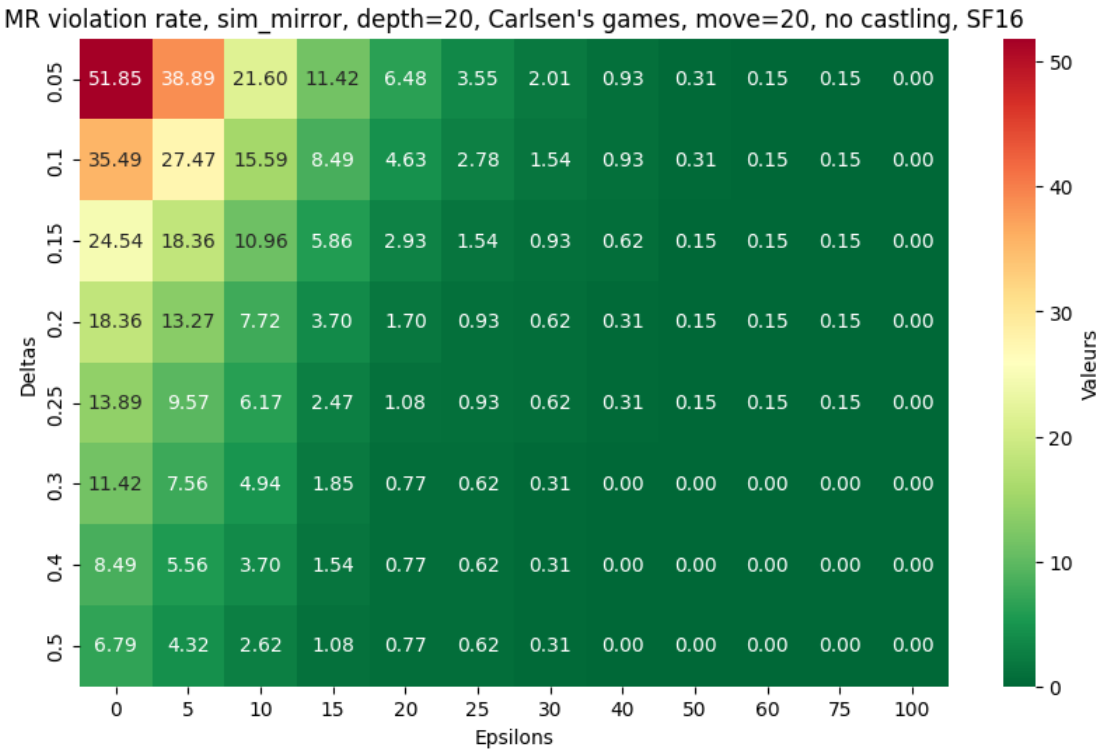
```
move = 20
```




**Carlsen's games, no castling available**

[627]:
```
path = os.path.join('reals','ev_Carlsen-20_nocastlingsim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs01620 = pickle.load(file)

print('move = 20')
tests(evs01620,0,20, ", Carlsen's games, move=20, no castling, SF16")
```

```
move = 20
```

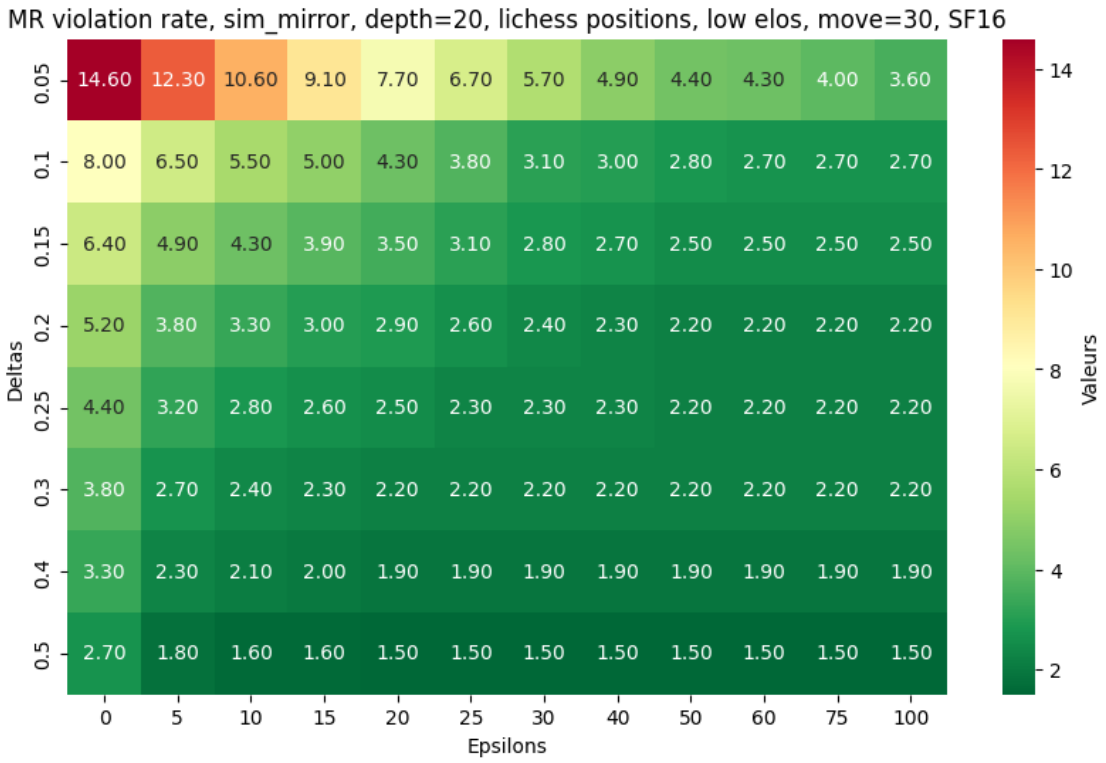



### Middle/Endgames (move=30)

### Lichess positions - 1000 to 1500 elo rating

[628]:
```
path = os.path.join('reals','ev_lichess1000-1500-30sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, low elos, move=30, SF16")
```

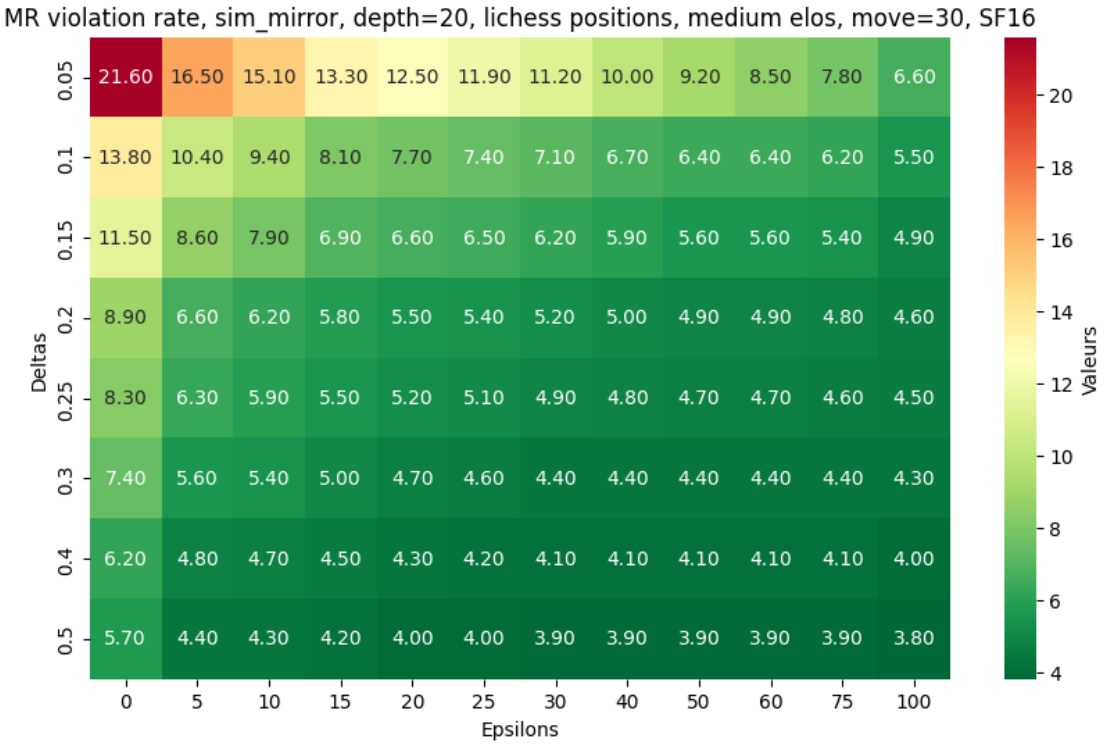
```
move = 30
```




**Lichess positions - 1500 to 2000 elo rating**

[629]:
```
path = os.path.join('reals','ev_lichess1500-2000-30sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, medium elos, move=30, SF16")
```

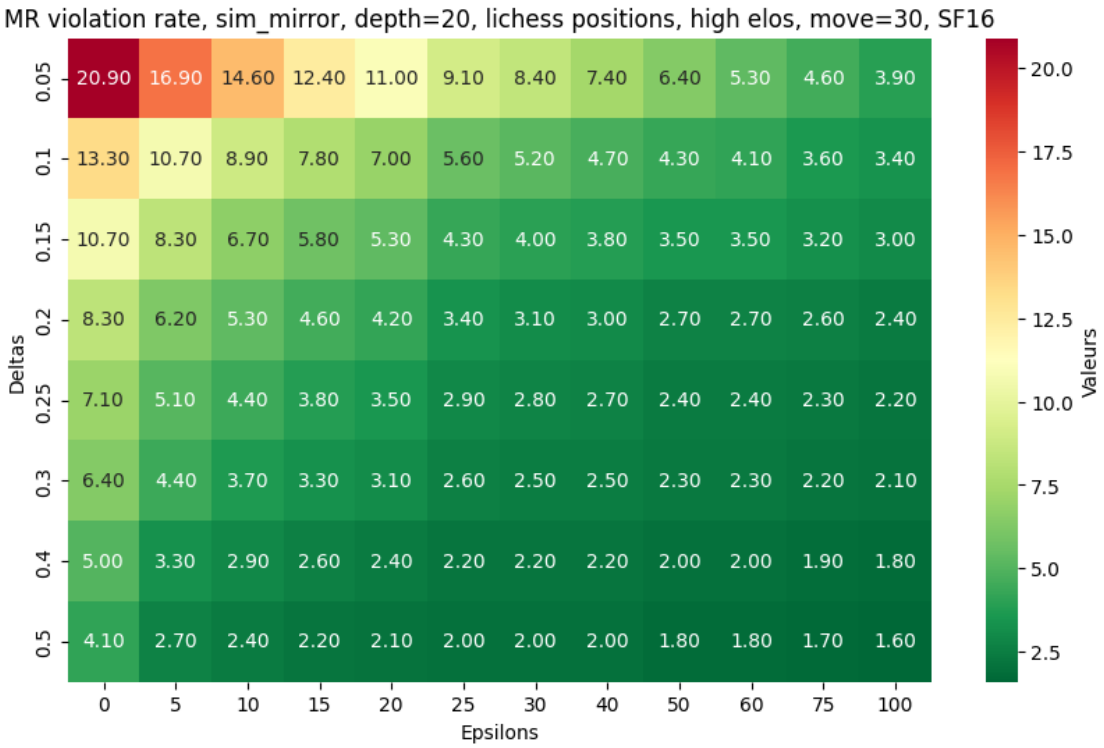
```
move = 30
```




**Lichess positions - 2000 to 2500 elo rating**

[630]:
```
path = os.path.join('reals','ev_lichess2000-2500-30sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, high elos, move=30, SF16")
```

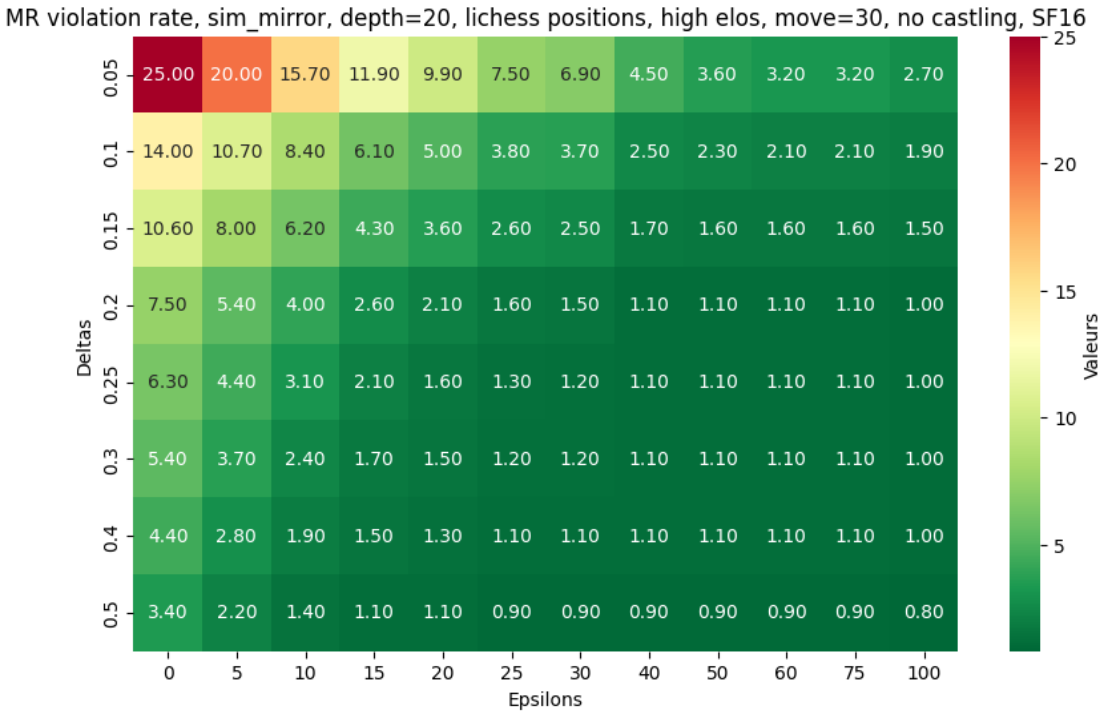
```
move = 30
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[631]:
```
path = os.path.
  ↪join('reals','ev_lichess2000-2500-30_nocastlingsim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, high elos, move=30, no castling, SF16")
```

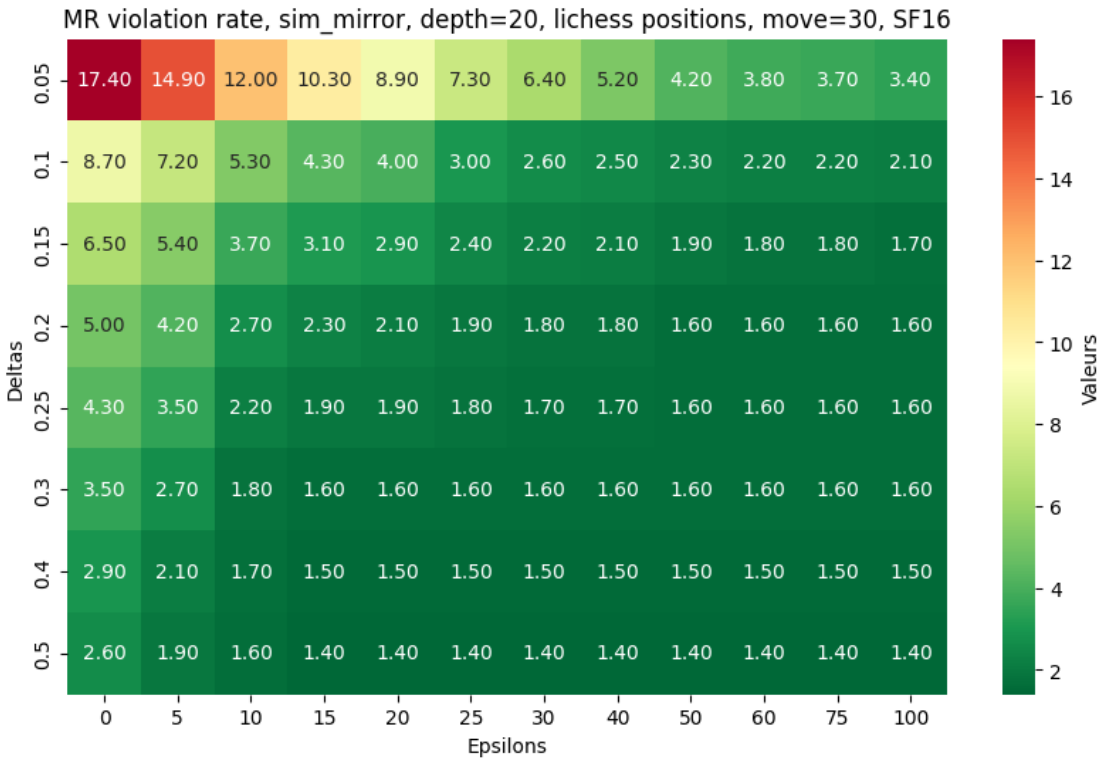
```
move = 30
```




**Lichess positions - All elos**

[632]:
```
path = os.path.join('reals','ev_lichessAllElos-30sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, move=30, SF16")
```

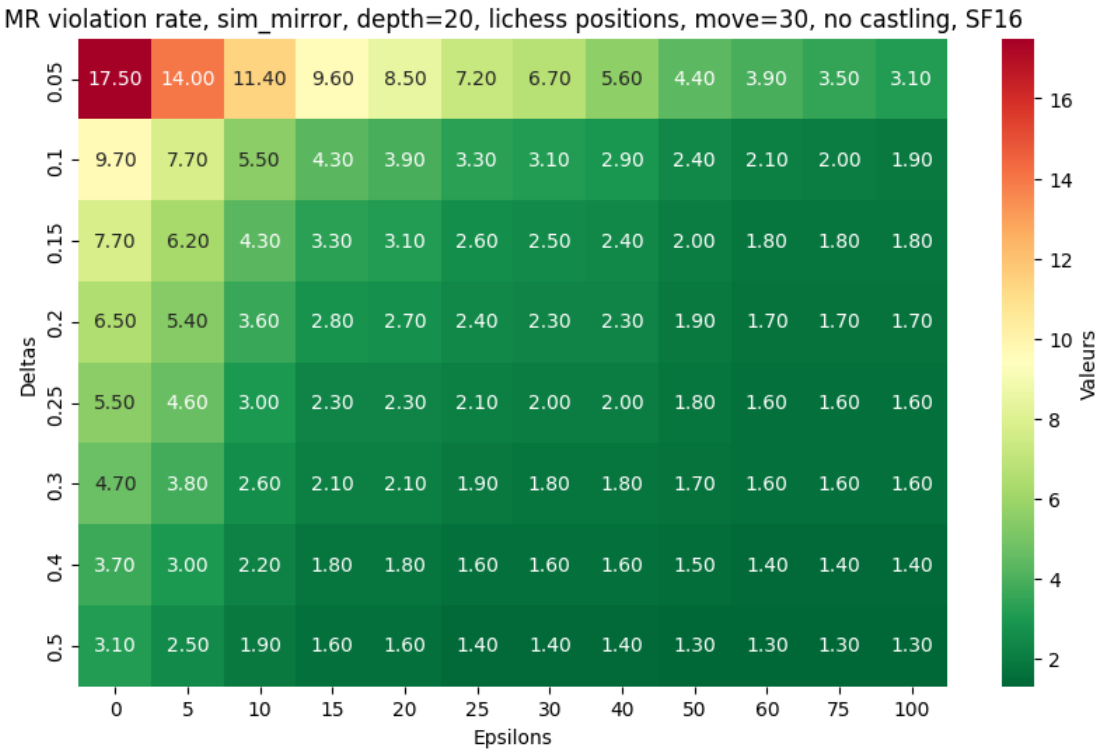
```
move = 30
```




**Lichess positions - All elos, no castling available**

[633]:
```
path = os.path.join('reals','ev_lichessAllElos-30_nocastlingsim_mirror_d_20_v16.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", lichess positions, move=30, no castling, SF16")
```

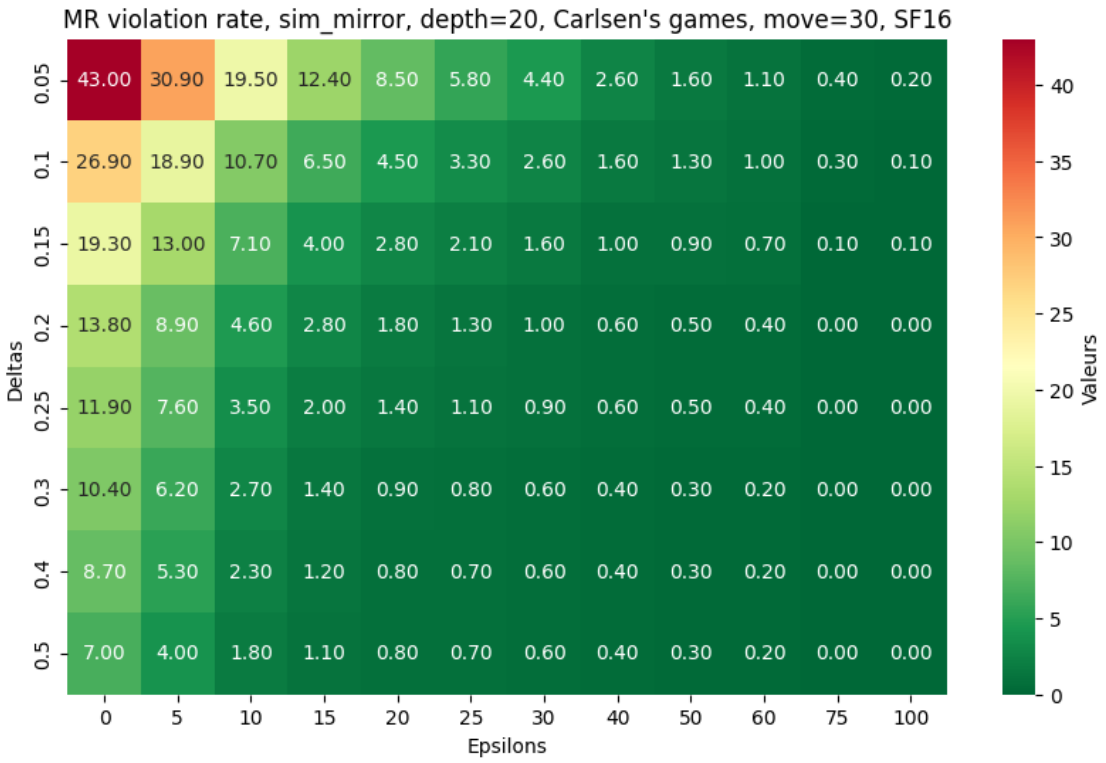
```
move = 30
```




### Carlsen's games

[634]:
```
path = os.path.join('reals','ev_Carlsen-30sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,0,20, ", Carlsen's games, move=30, SF16")
```

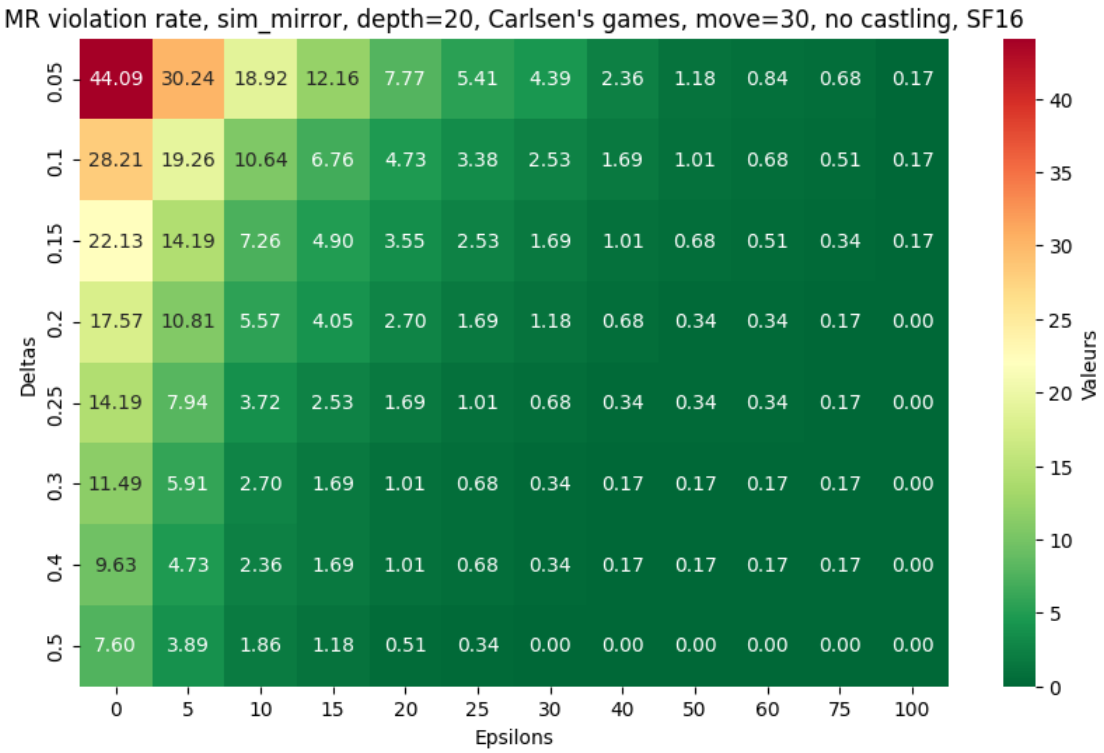
```
move = 30
```




**Carlsen's games, no castling avaialble**

[635]:
```
path = os.path.join('reals','ev_Carlsen-30_nocastlingsim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs01630 = pickle.load(file)

print('move = 30')
tests(evs01630,0,20, ", Carlsen's games, move=30, no castling, SF16")
```

```
move = 30
```

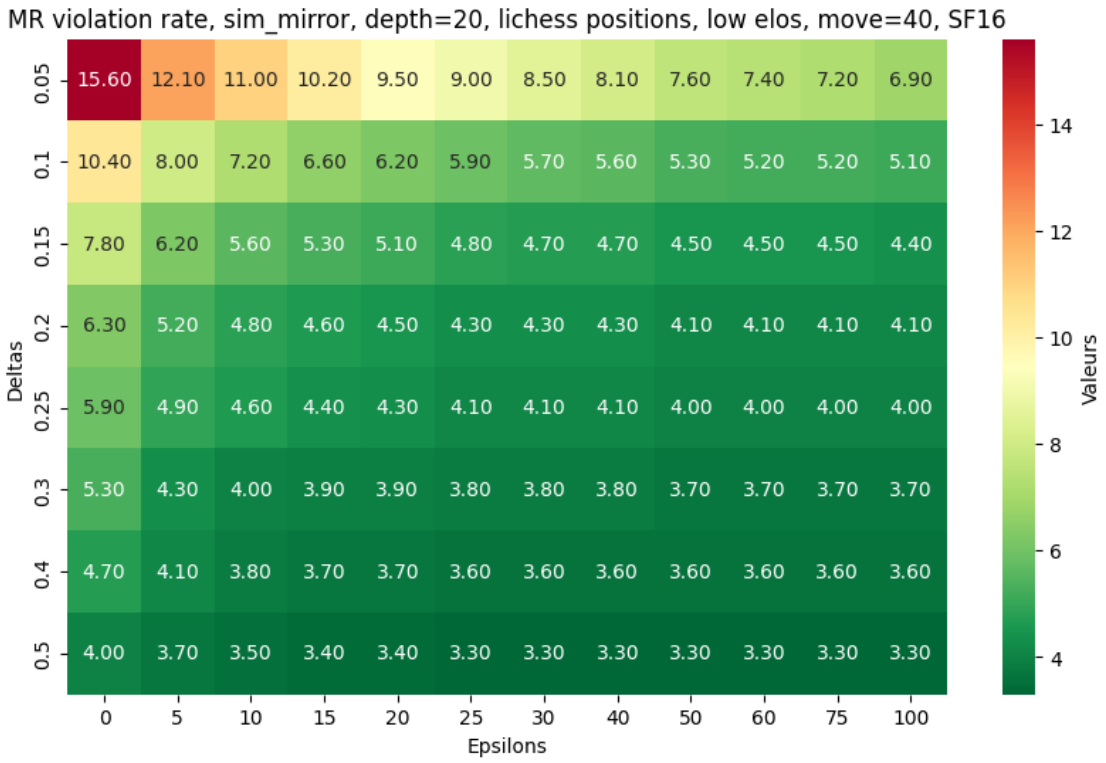



### Endgames (move=40)

### Lichess positions - 1000 to 1500 elo rating

[636]:
```
path = os.path.join('reals','ev_lichess1000-1500-40sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, low elos, move=40, SF16")
```

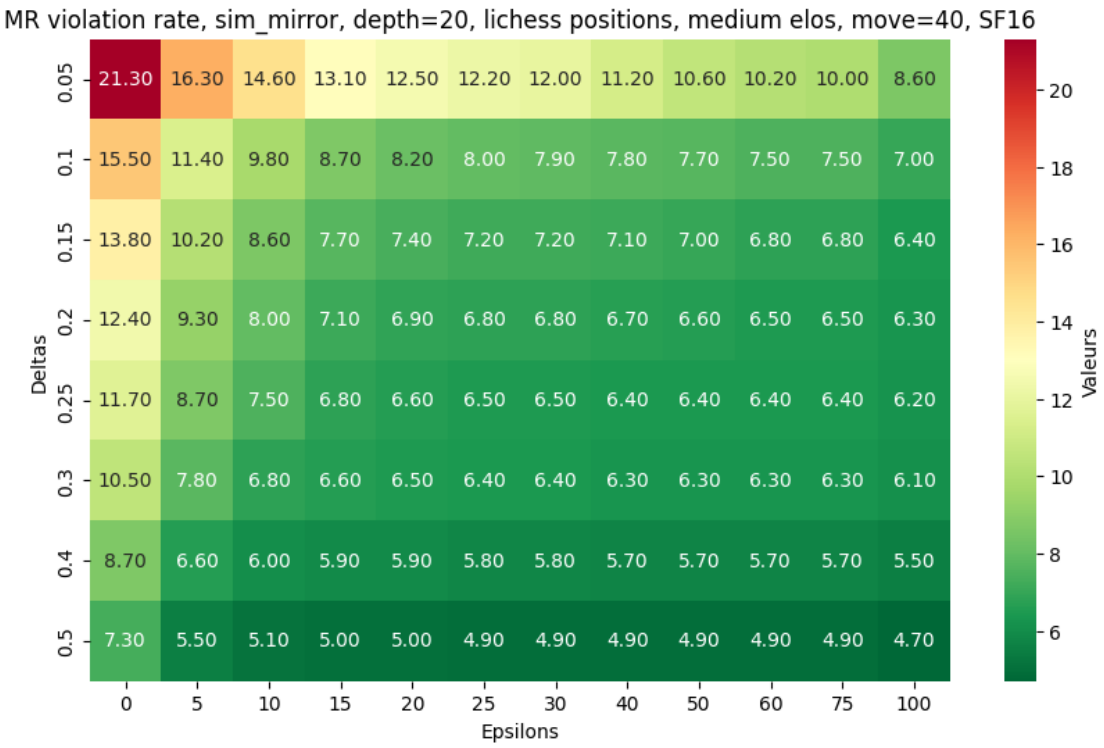
```
move = 40
```




**Lichess positions - 1500 to 2000 elo rating**

[637]:
```
path = os.path.join('reals','ev_lichess1500-2000-40sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, medium elos, move=40, SF16")
```

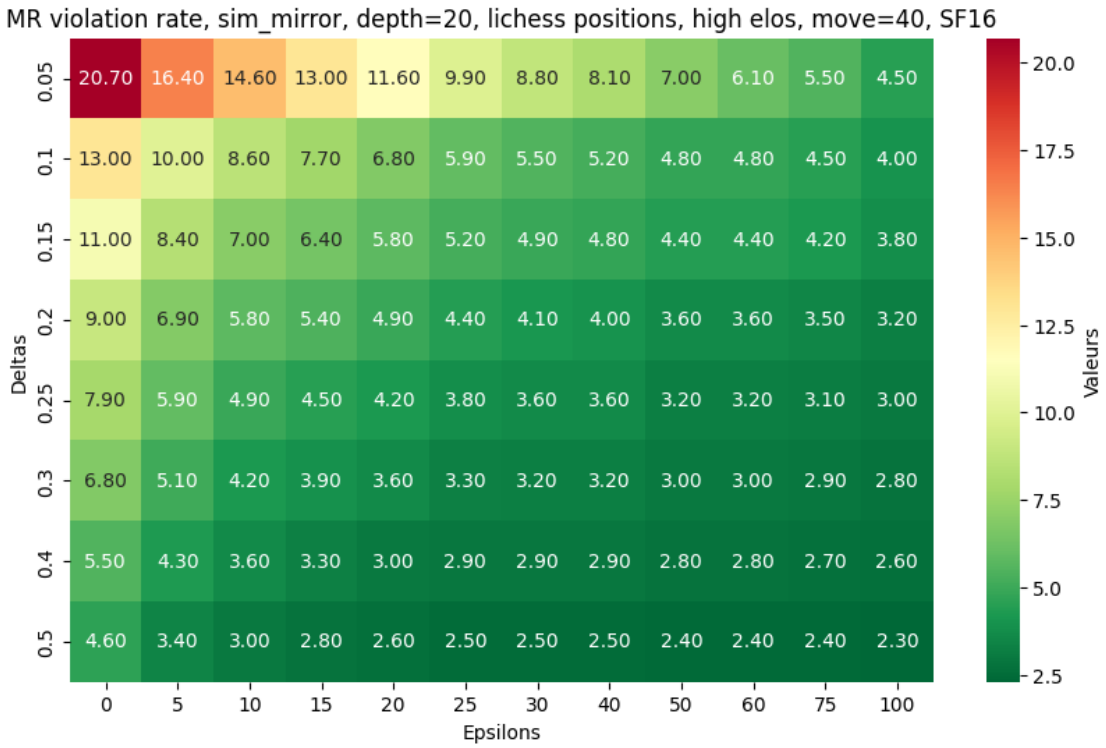
```
move = 40
```




**Lichess positions - 2000 to 2500 elo rating**

[638]:
```
path = os.path.join('reals','ev_lichess2000-2500-40sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, high elos, move=40, SF16")
```

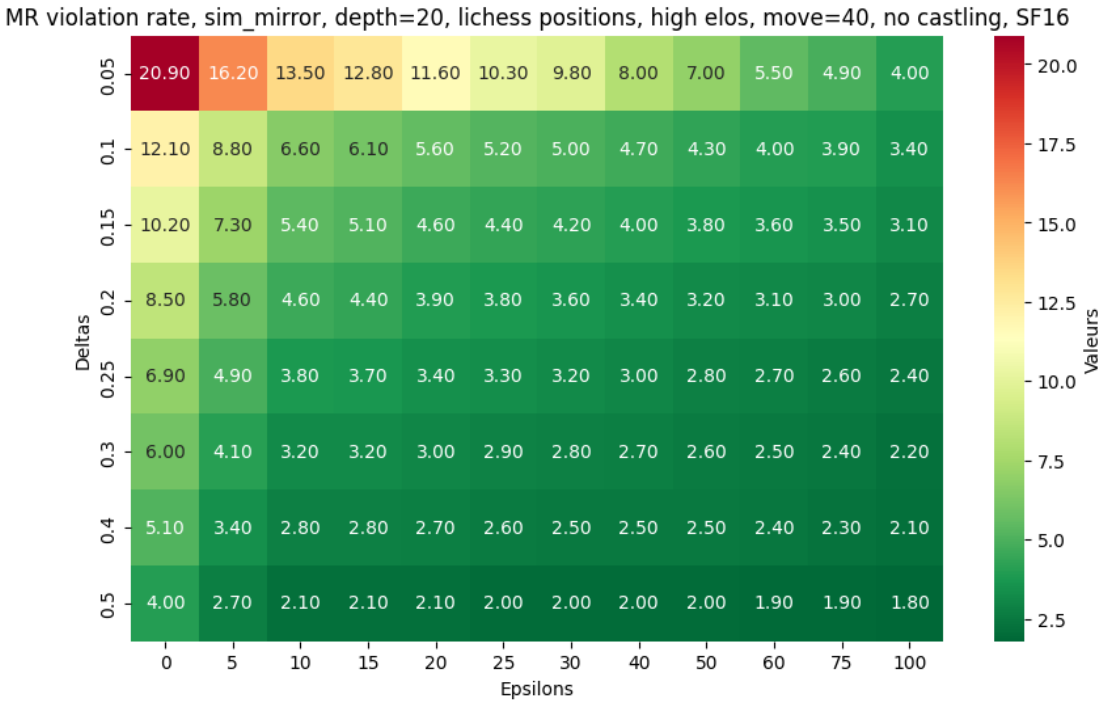
```
move = 40
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[639]:
```
path = os.path.
  ↪join('reals','ev_lichess2000-2500-40_nocastlingsim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, high elos, move=40, no castling, SF16")
```

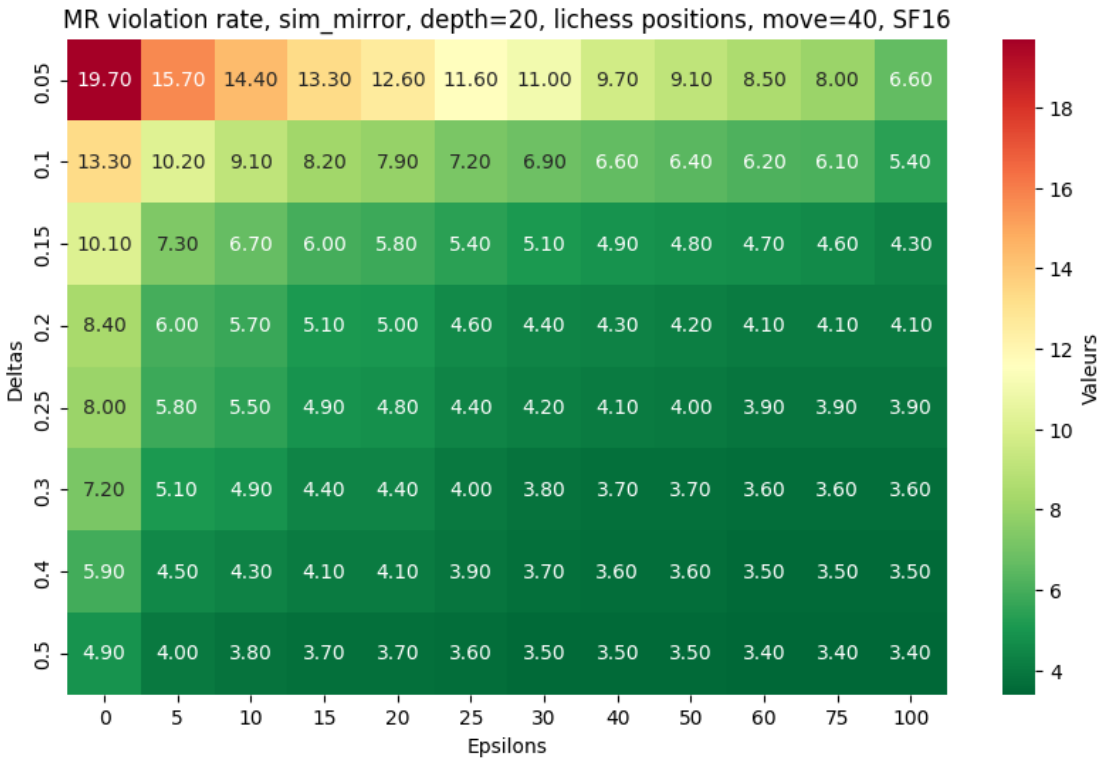
```
move = 40
```




### Lichess positions - All elos

[640]:
```
path = os.path.join('reals','ev_lichessAllElos-40sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, move=40, SF16")
```

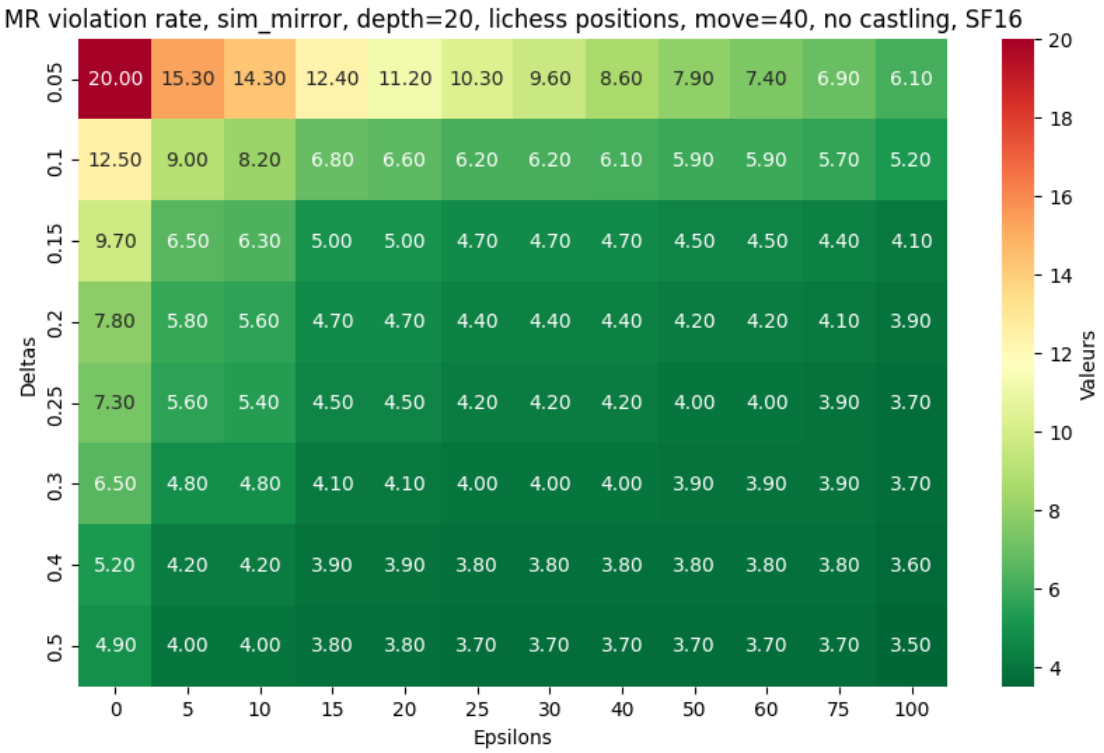
```
move = 40
```




**Lichess positions - All elos, no castling available**

[641]:
```
path = os.path.join('reals','ev_lichessAllElos-40_nocastlingsim_mirror_d_20_v16.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", lichess positions, move=40, no castling, SF16")
```

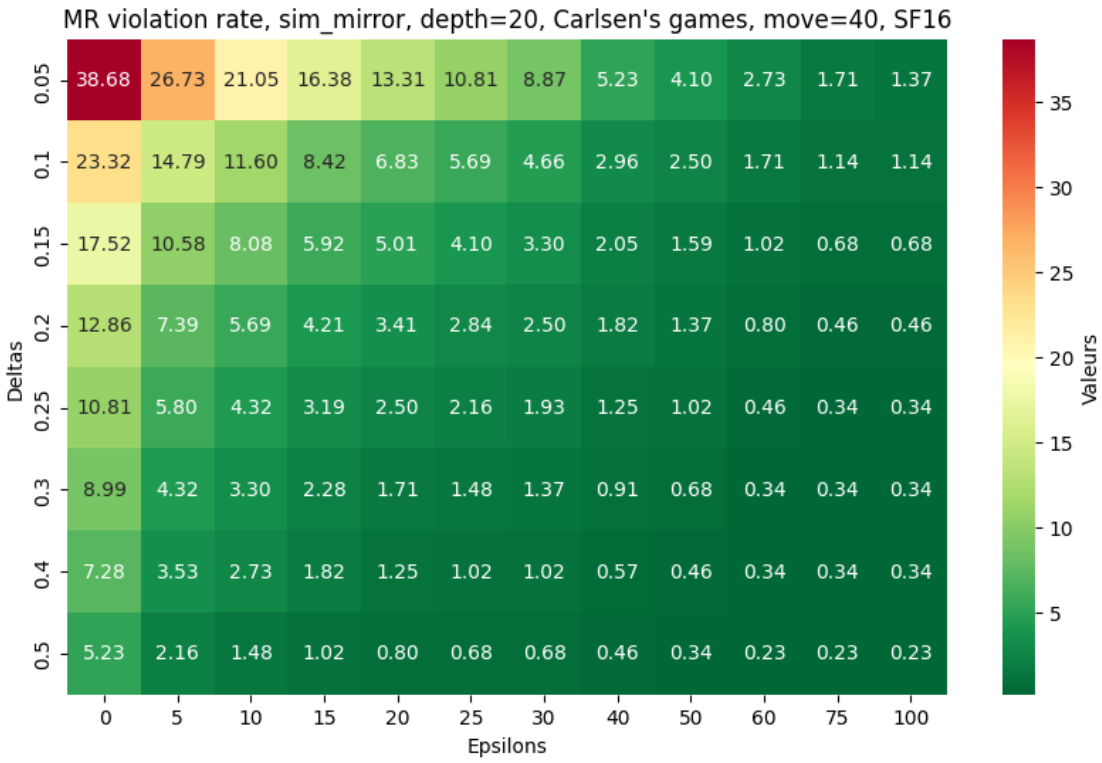
```
move = 40
```




### Carlsen's games

[642]:
```
path = os.path.join('reals','ev_Carlsen-40sim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,0,20, ", Carlsen's games, move=40, SF16")
```

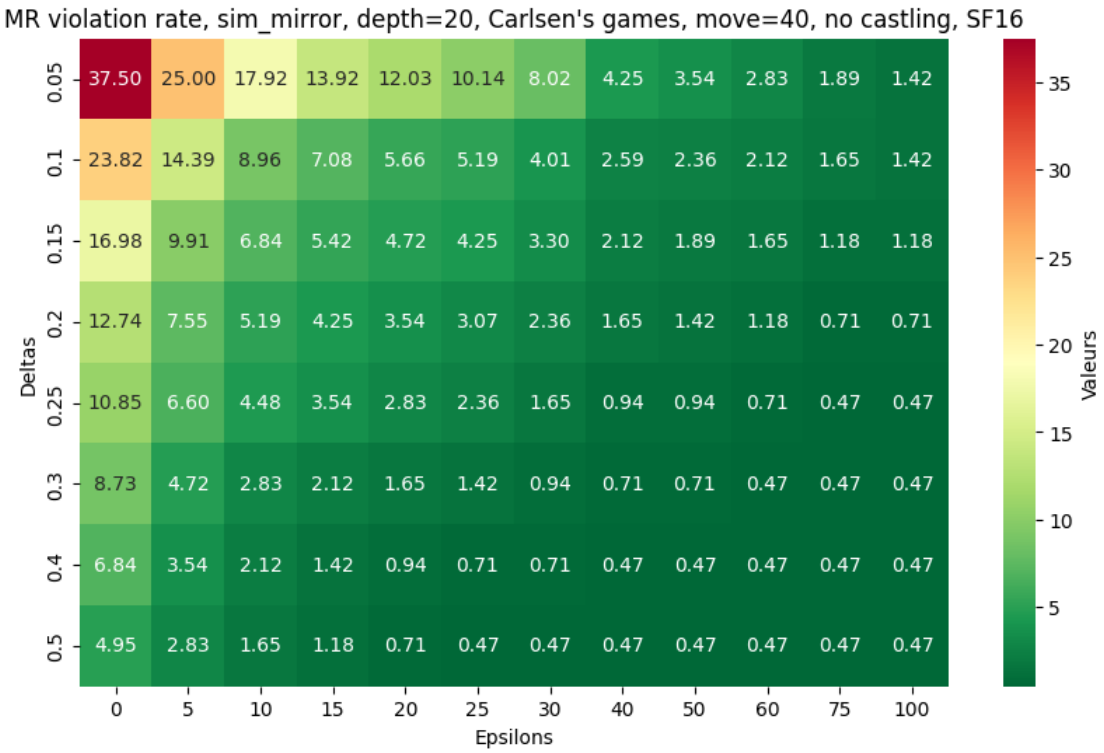
```
move = 40
```




**Carlsen's games, no castling available**

[643]:
```
path = os.path.join('reals','ev_Carlsen-40_nocastlingsim_mirror_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs01640 = pickle.load(file)

print('move = 40')
tests(evs01640,0,20, ", Carlsen's games, move=40, no castling, SF16")
```

```
move = 40
```



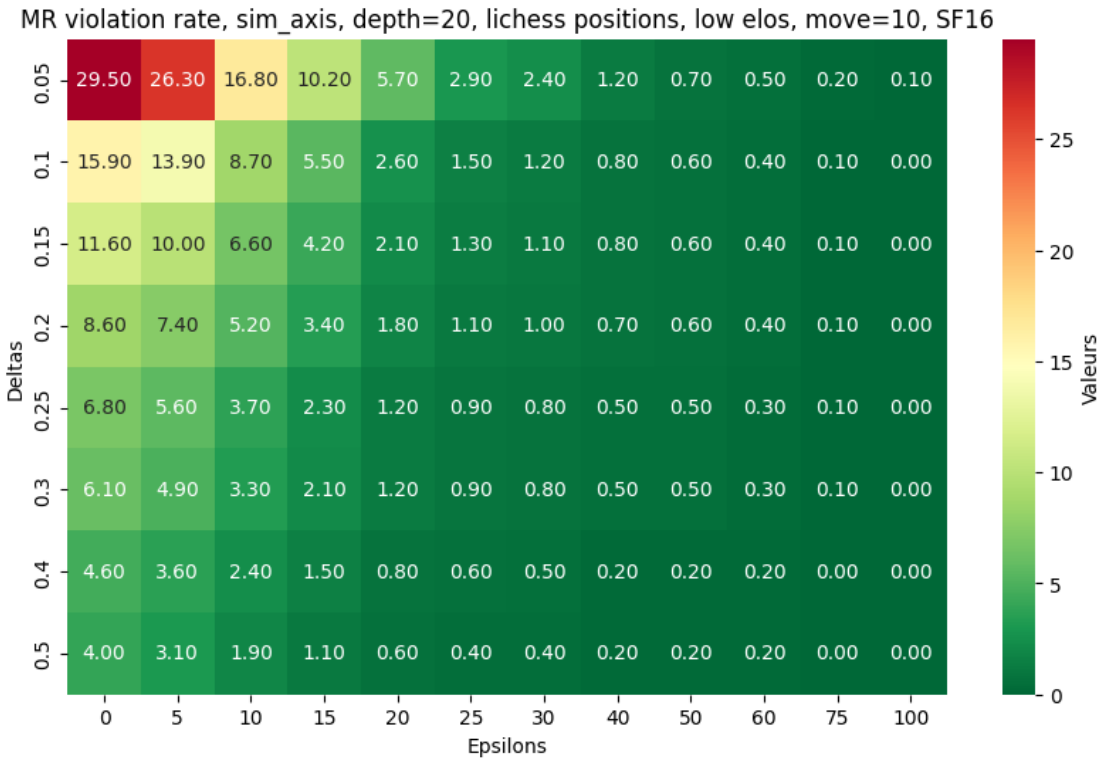

### 0.12.2 sim_axis

**Openings (move=10)**

**Lichess positions - 1000 to 1500 elo rating**

[644]:
```
path = os.path.join('reals','ev_lichess1000-1500-10sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, low elos, move=10, SF16")
```

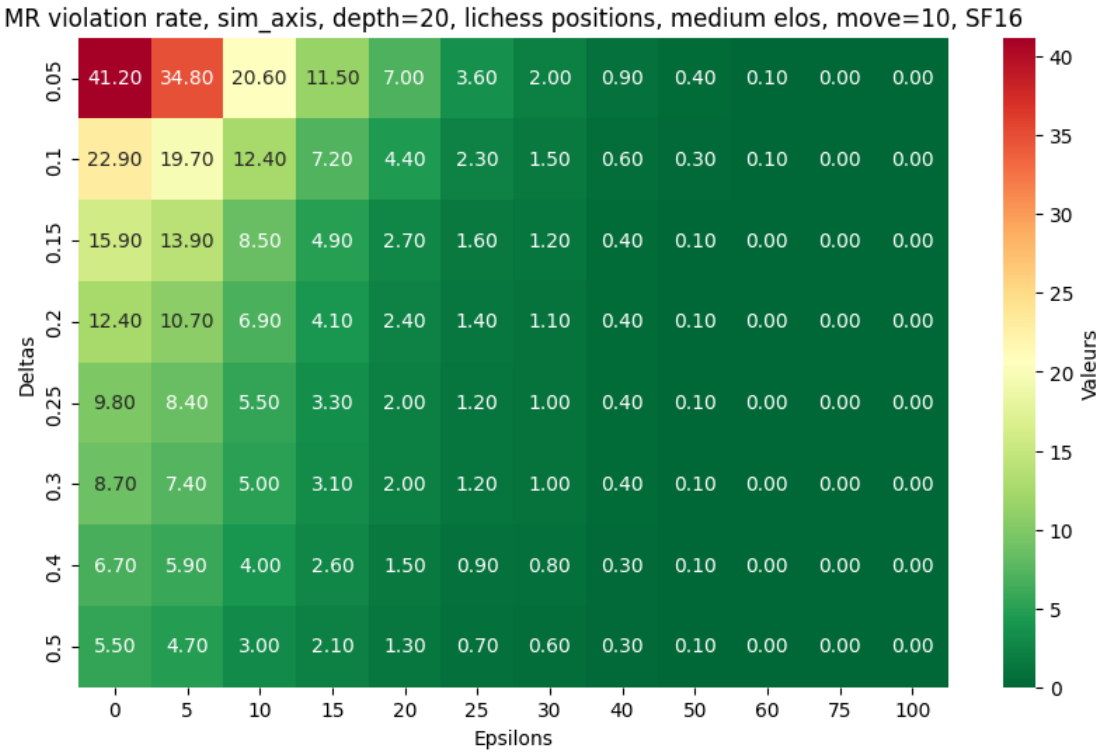
```
move = 10
```




### Lichess positions - 1500 to 2000 elo rating

[645]:
```
path = os.path.join('reals','ev_lichess1500-2000-10sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, medium elos, move=10, SF16")
```

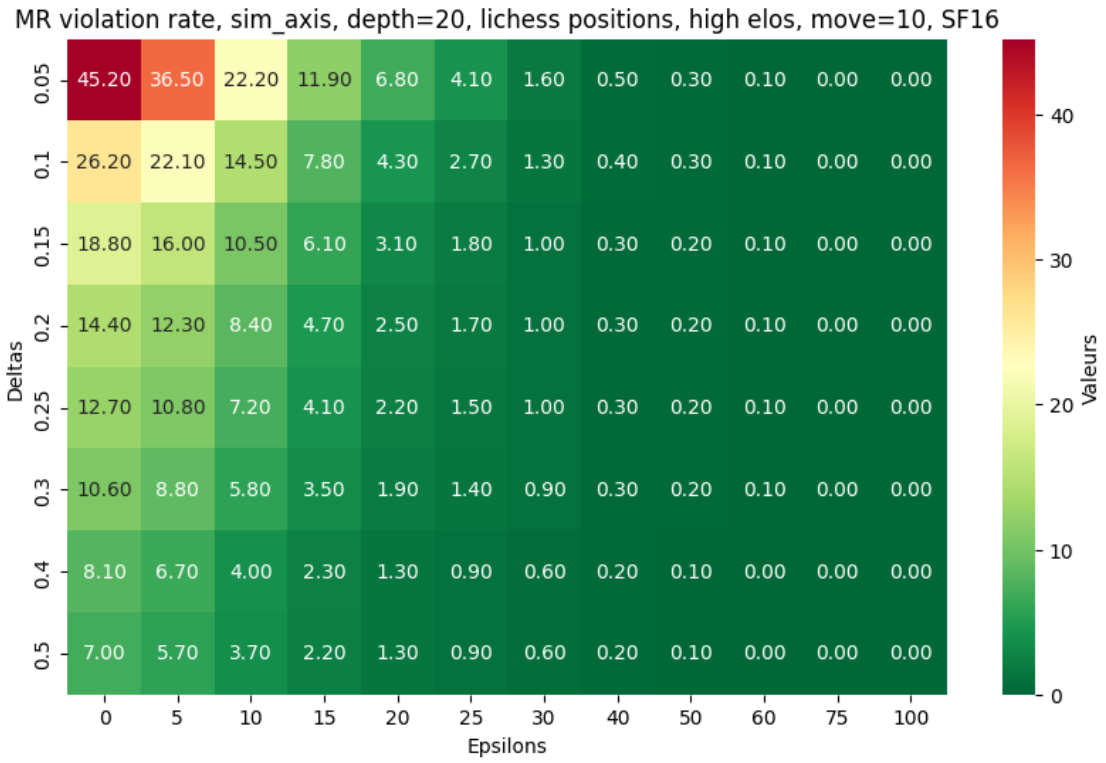
```
move = 10
```




**Lichess positions - 2000 to 2500 elo rating**

[646]:
```
path = os.path.join('reals','ev_lichess2000-2500-10sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, high elos, move=10, SF16")
```

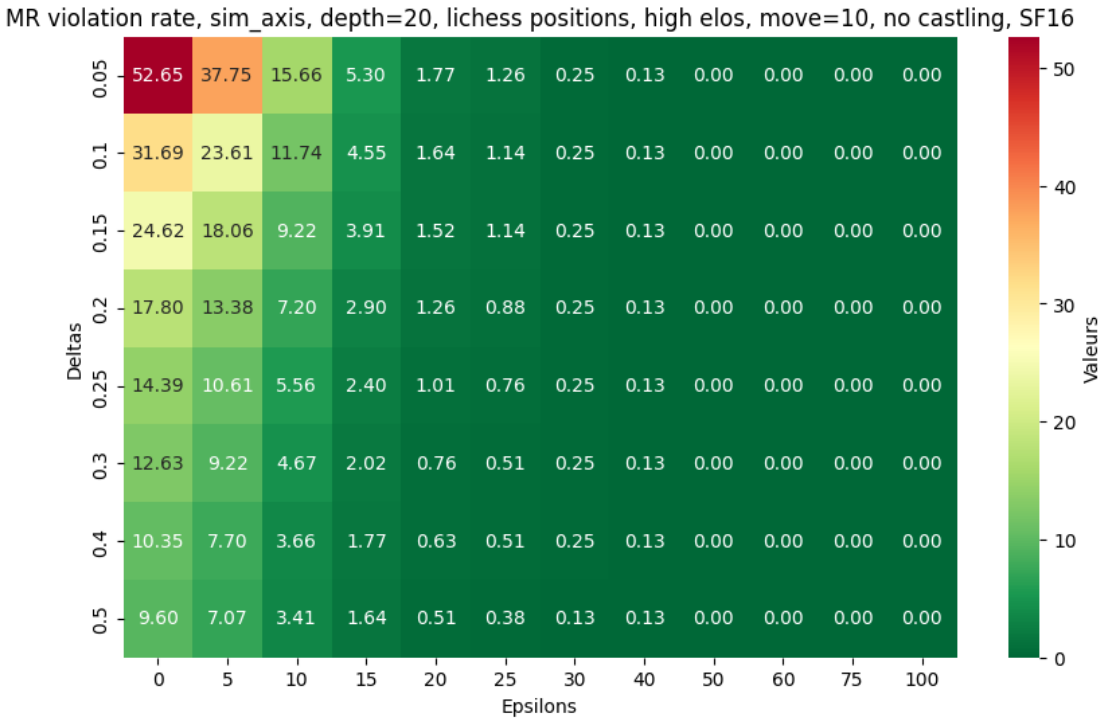
```
move = 10
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[647]:
```
path = os.path.join('reals','ev_lichess2000-2500-10_nocastlingsim_axis_d_20_v16.
  ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, high elos, move=10, no castling, SF16")
```

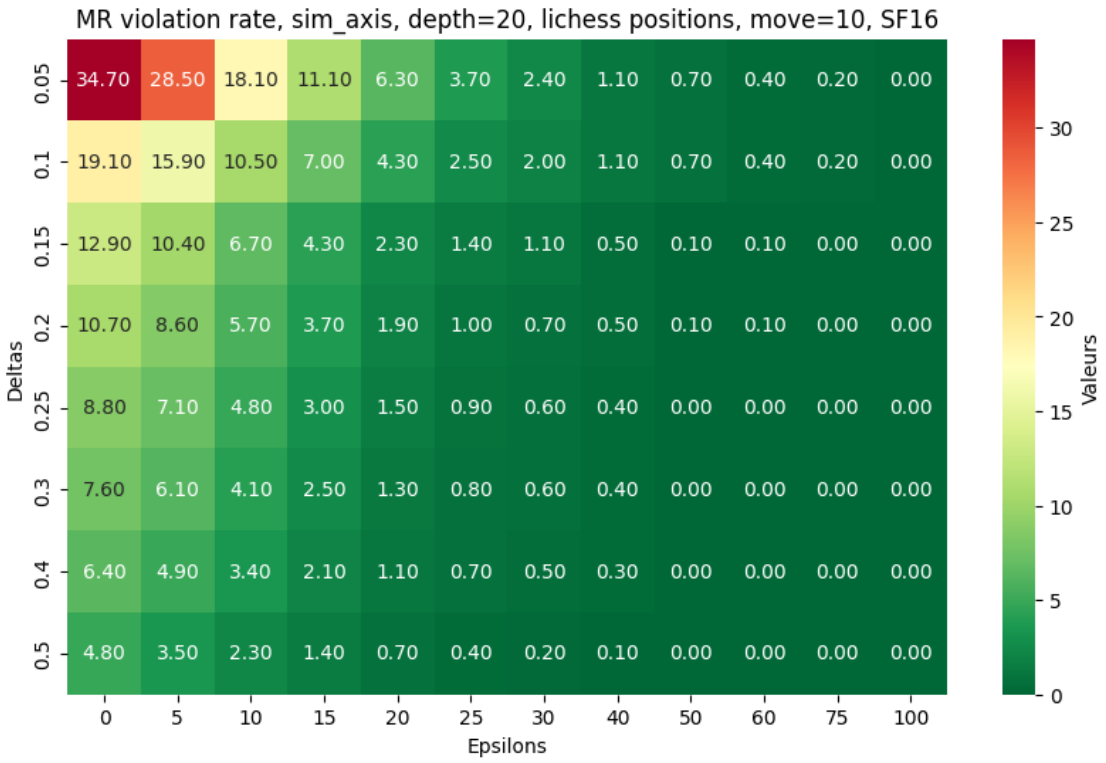
```
move = 10
```




### Lichess positions - All elos

[648]:
```
path = os.path.join('reals','ev_lichessAllElos-10sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, move=10, SF16")
```

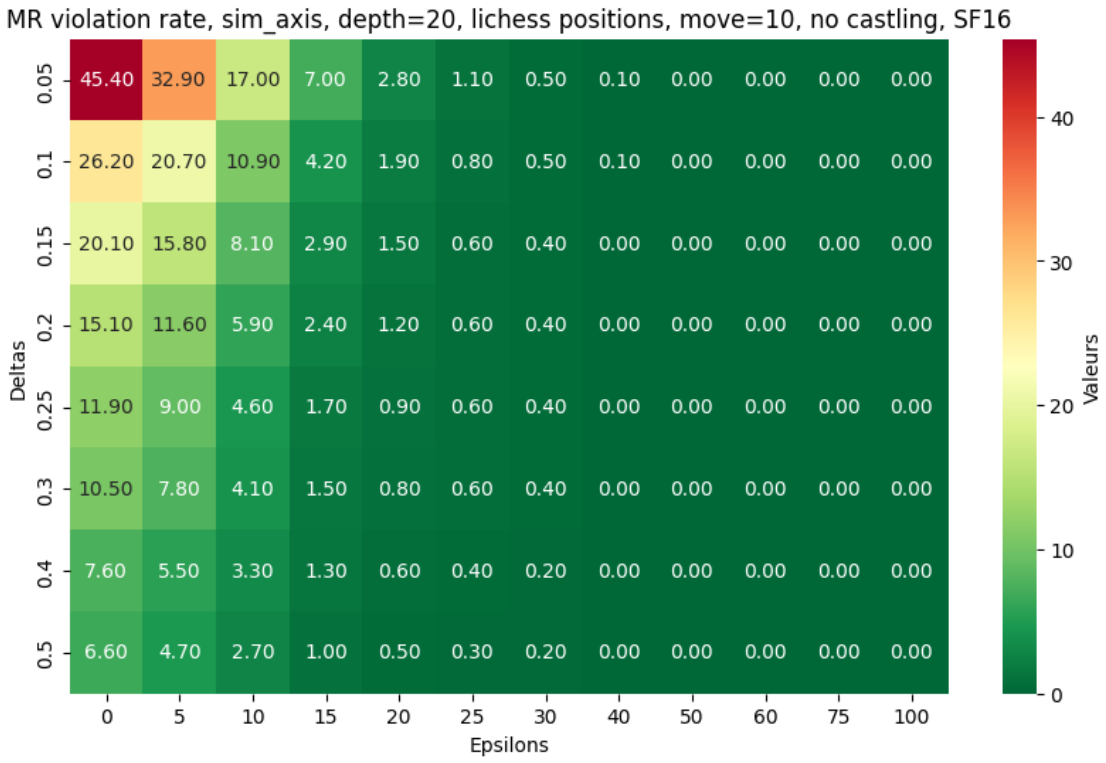
```
move = 10
```




**Lichess positions - All elos, no castling available**

[649]:
```
path = os.path.join('reals','ev_lichessAllElos-10_nocastlingsim_axis_d_20_v16.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", lichess positions, move=10, no castling, SF16")
```

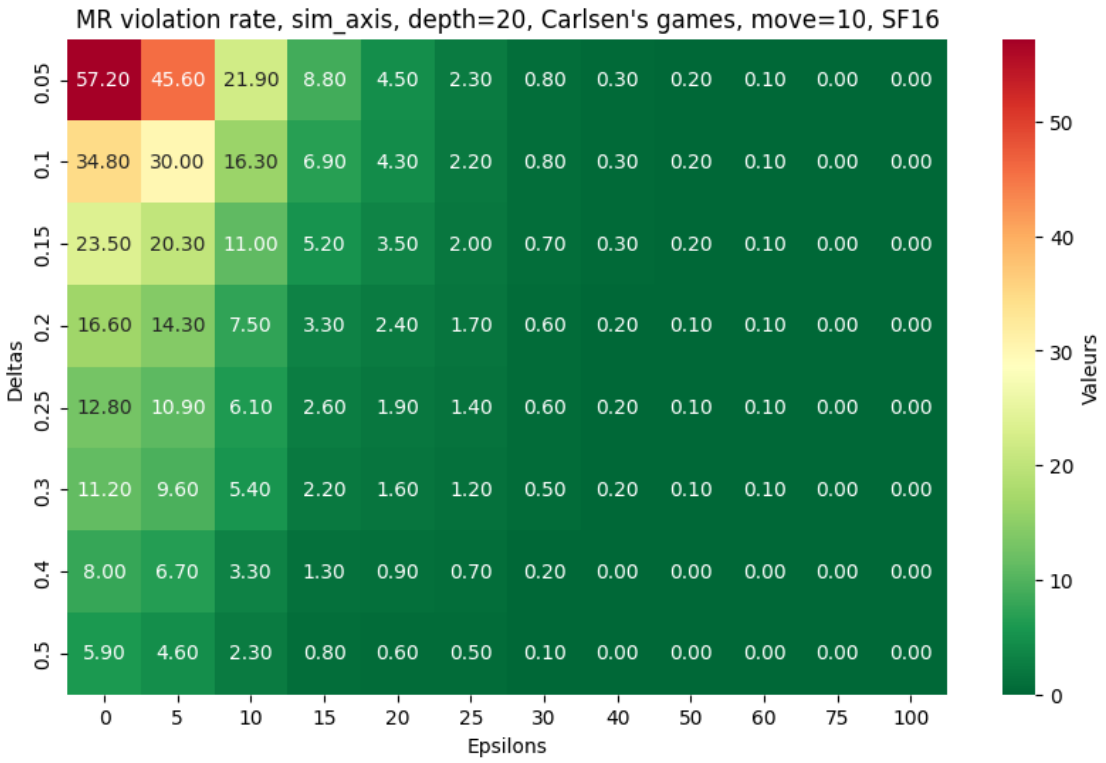
```
move = 10
```




### Carlsen's games

[660]:
```
path = os.path.join('reals','ev_Carlsen-10sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 10')
tests(evs,1,20, ", Carlsen's games, move=10, SF16")
```

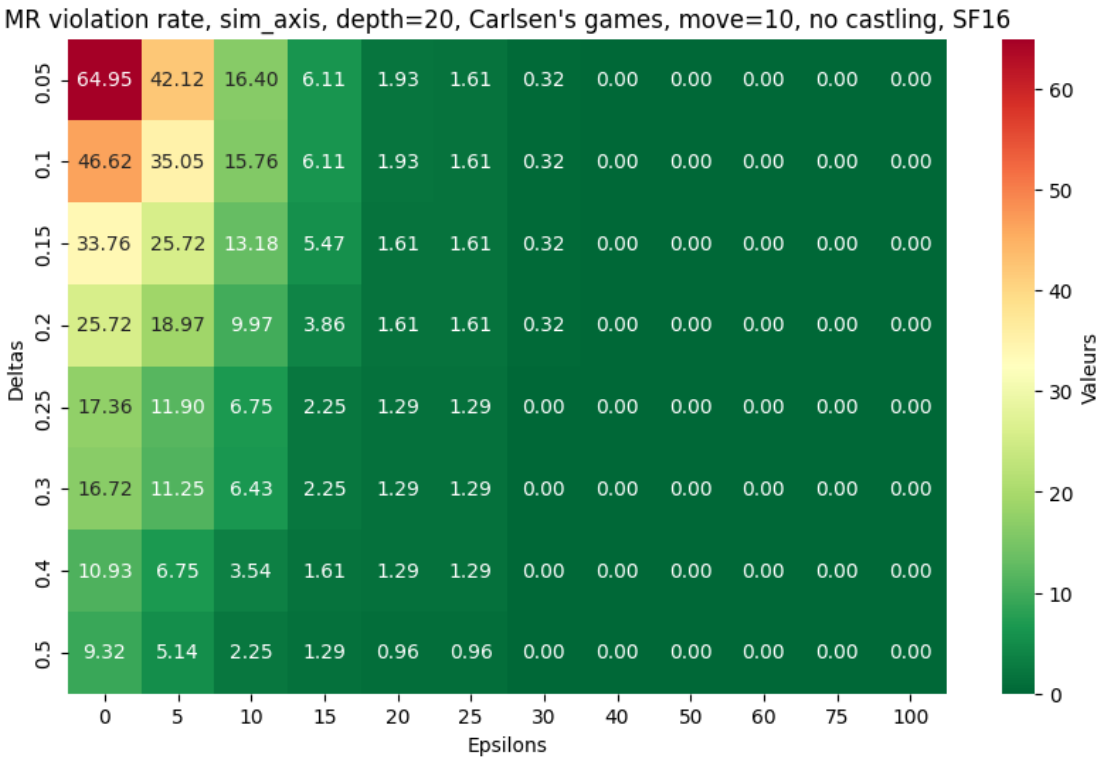
```
move = 10
```




**Carlsen's games, no castling available**

[651]:
```
path = os.path.join('reals','ev_Carlsen-10_nocastlingsim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs11610 = pickle.load(file)

print('move = 10')
tests(evs11610,1,20, ", Carlsen's games, move=10, no castling, SF16")
```

```
move = 10
```

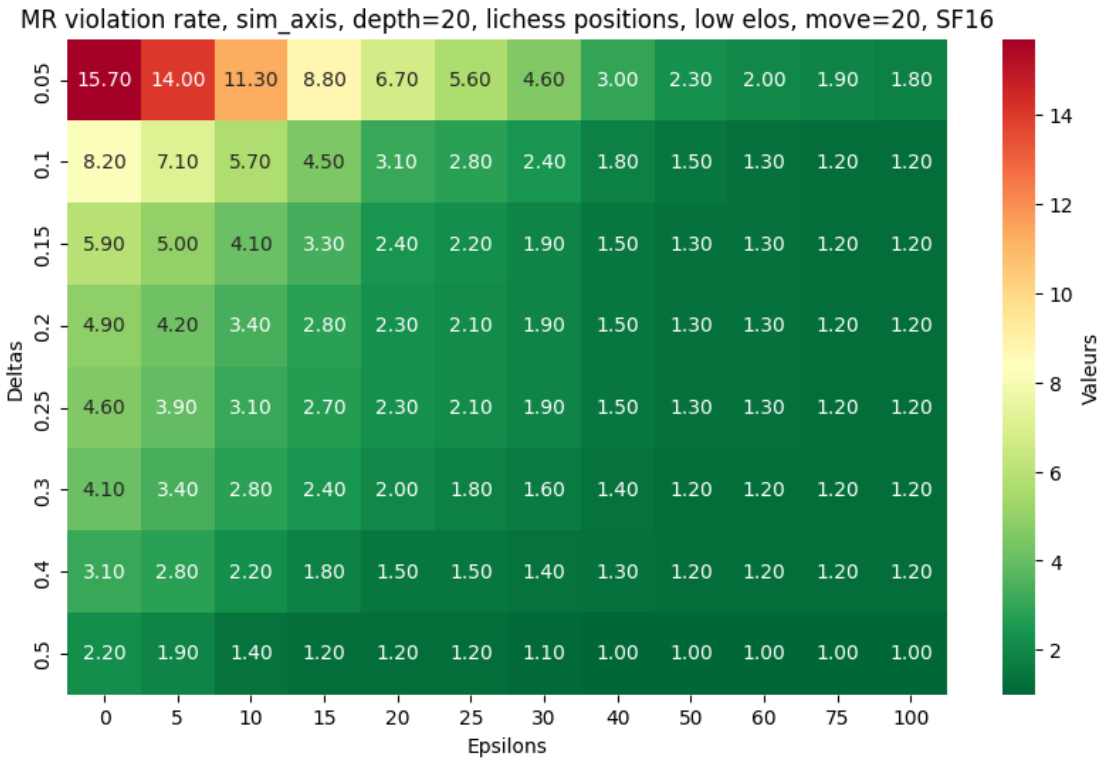



### Middlegames (move=20)

### Lichess positions - 1000 to 1500 elo rating

[652]:
```
path = os.path.join('reals','ev_lichess1000-1500-20sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, low elos, move=20, SF16")
```

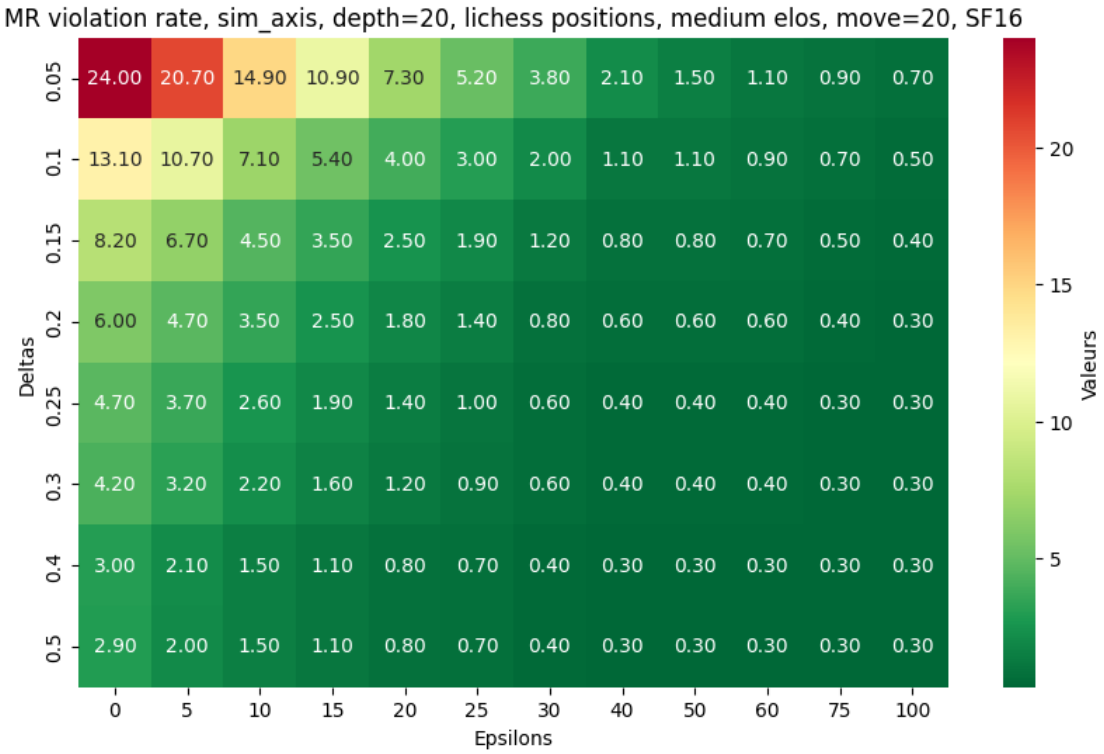
```
move = 20
```




**Lichess positions - 1500 to 2000 elo rating**

[653]:
```
path = os.path.join('reals','ev_lichess1500-2000-20sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, medium elos, move=20, SF16")
```

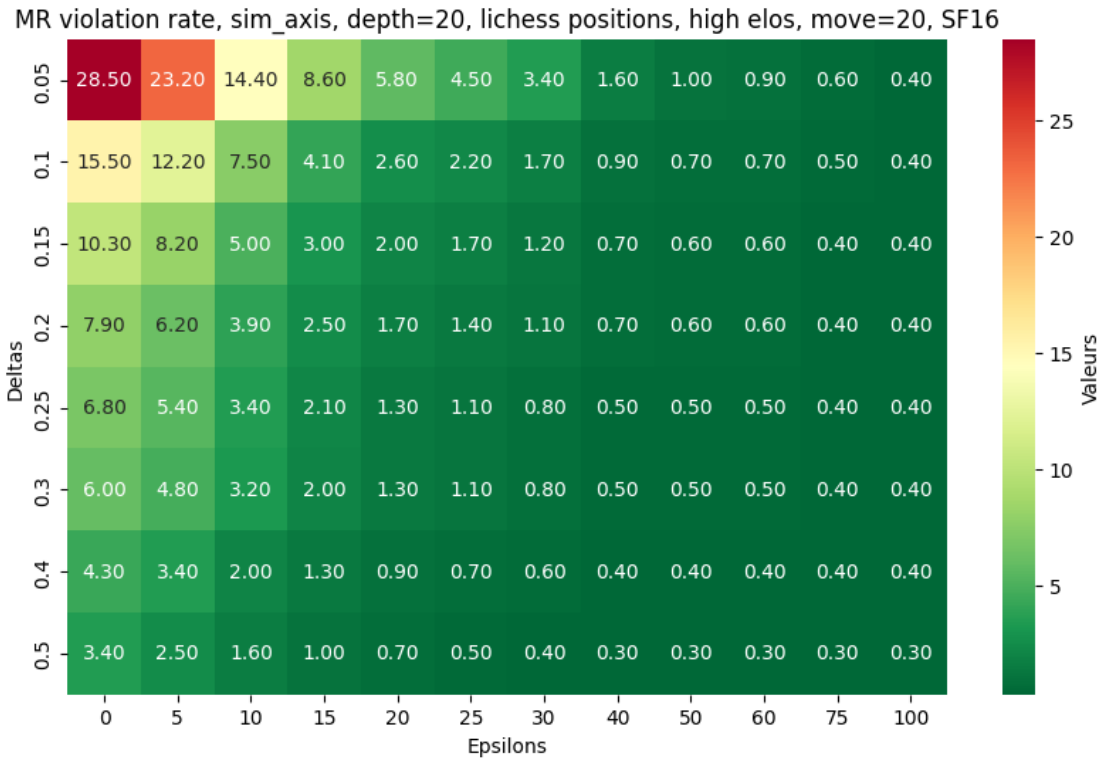
```
move = 20
```




**Lichess positions - 2000 to 2500 elo rating**

[654]:
```
path = os.path.join('reals','ev_lichess2000-2500-20sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, high elos, move=20, SF16")
```

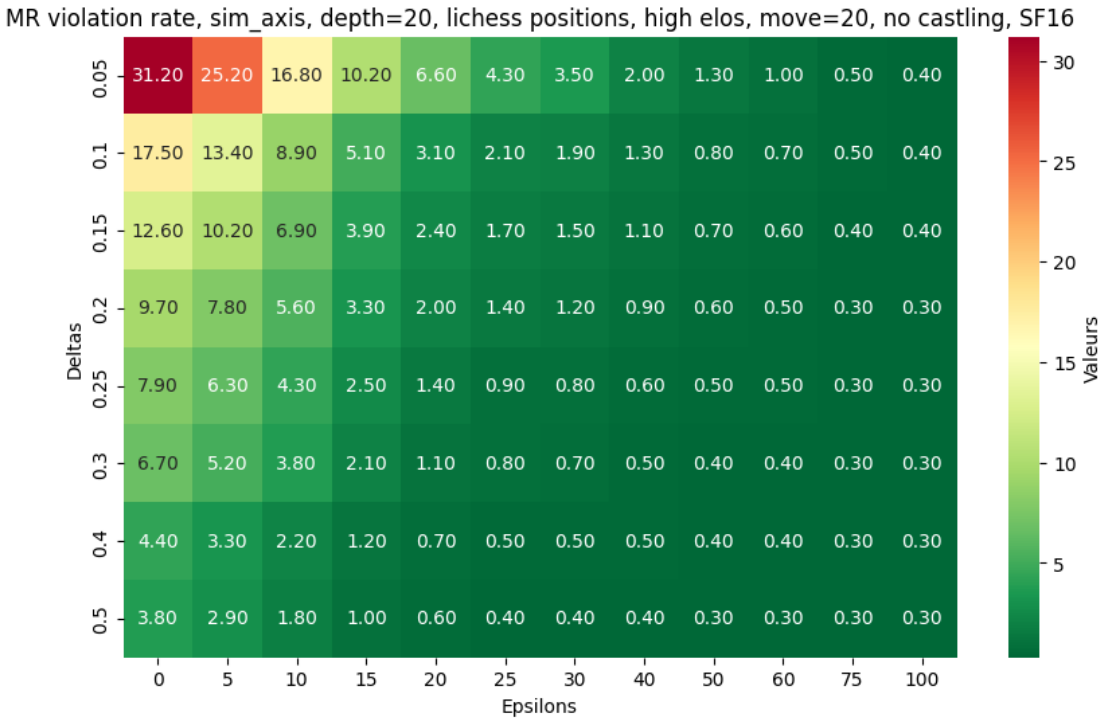
```
move = 20
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[656]:
```
path = os.path.join('reals','ev_lichess2000-2500-20_nocastlingsim_axis_d_20_v16.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, high elos, move=20, no castling, SF16")
```

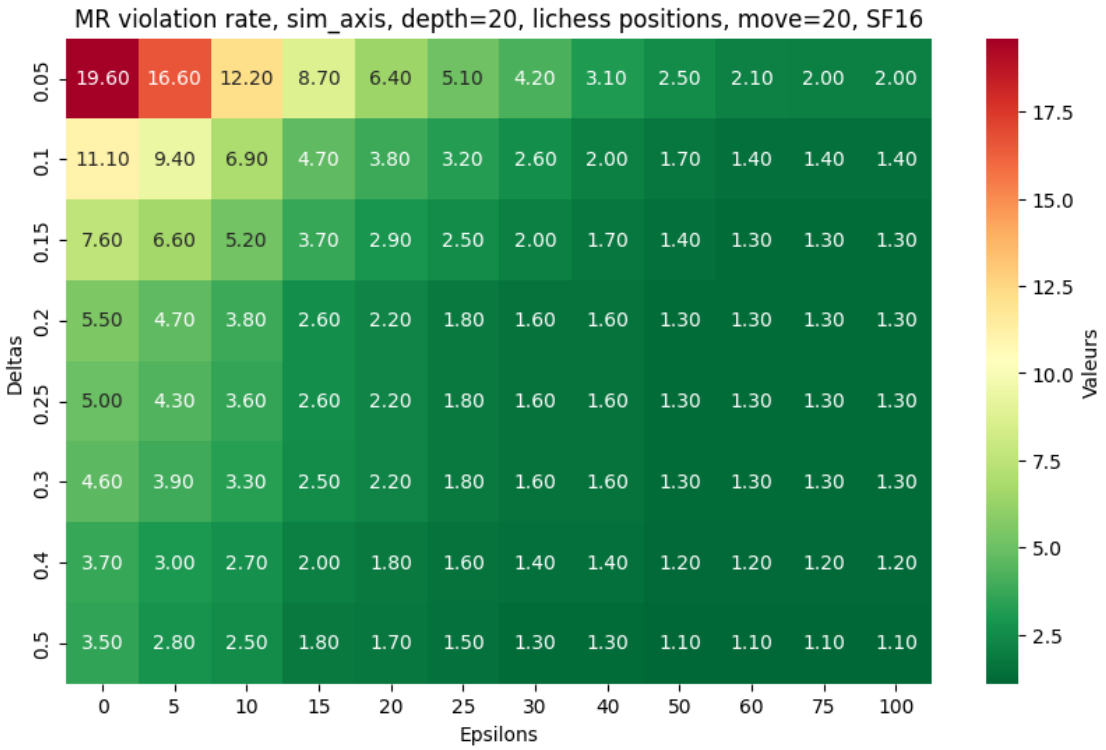
```
move = 20
```




### Lichess positions - All elos

[657]:
```
path = os.path.join('reals','ev_lichessAllElos-20sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, move=20, SF16")
```

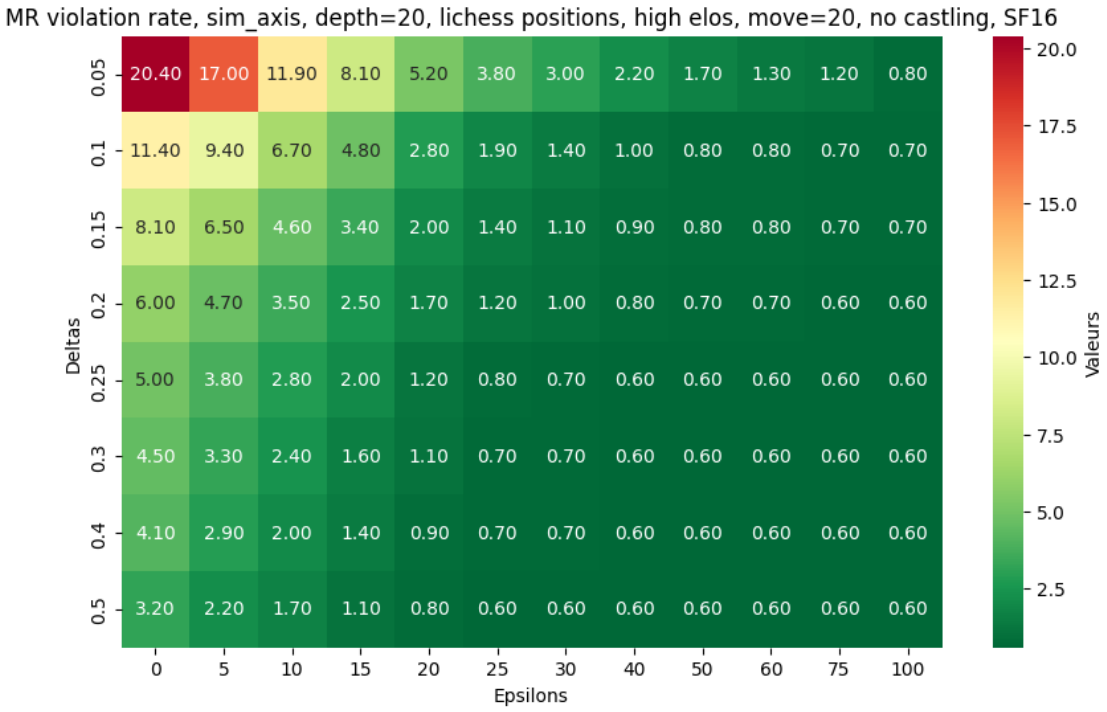
```
move = 20
```




**Lichess positions - All elos, no castling available**

[658]:
```
path = os.path.join('reals','ev_lichessAllElos-20_nocastlingsim_axis_d_20_v16.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", lichess positions, high elos, move=20, no castling, SF16")
```

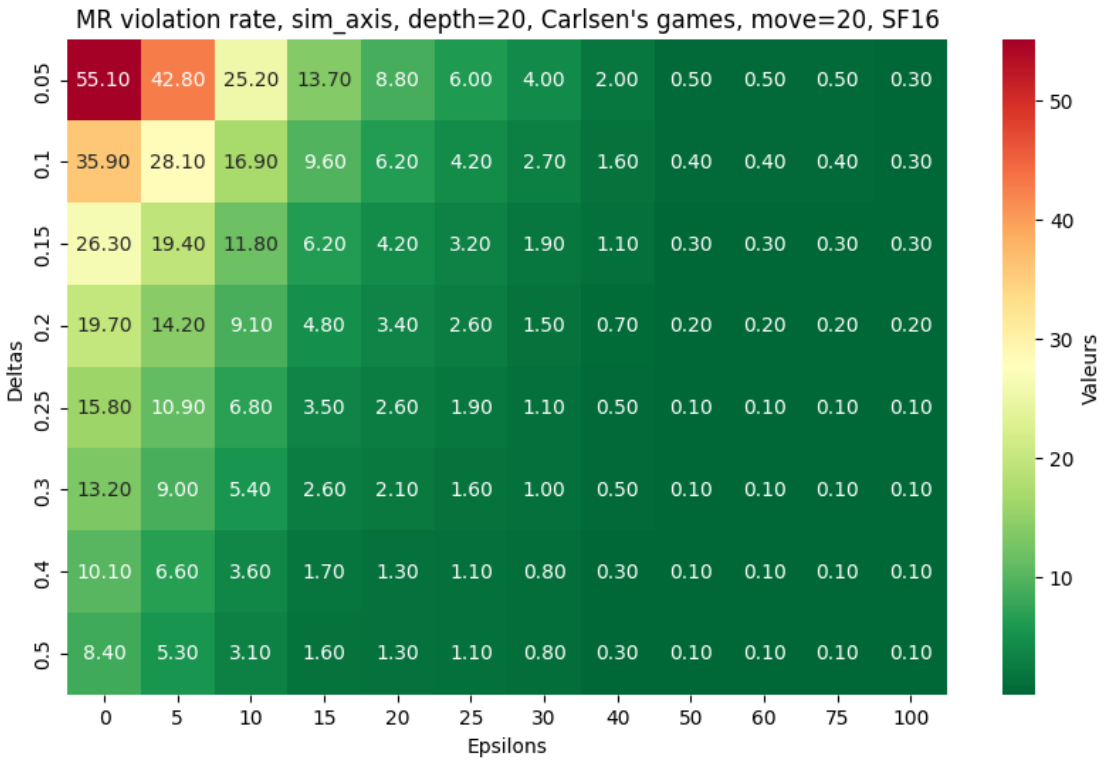
```
move = 20
```




### Carlsen's games

[659]:
```
path = os.path.join('reals','ev_Carlsen-20sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 20')
tests(evs,1,20, ", Carlsen's games, move=20, SF16")
```

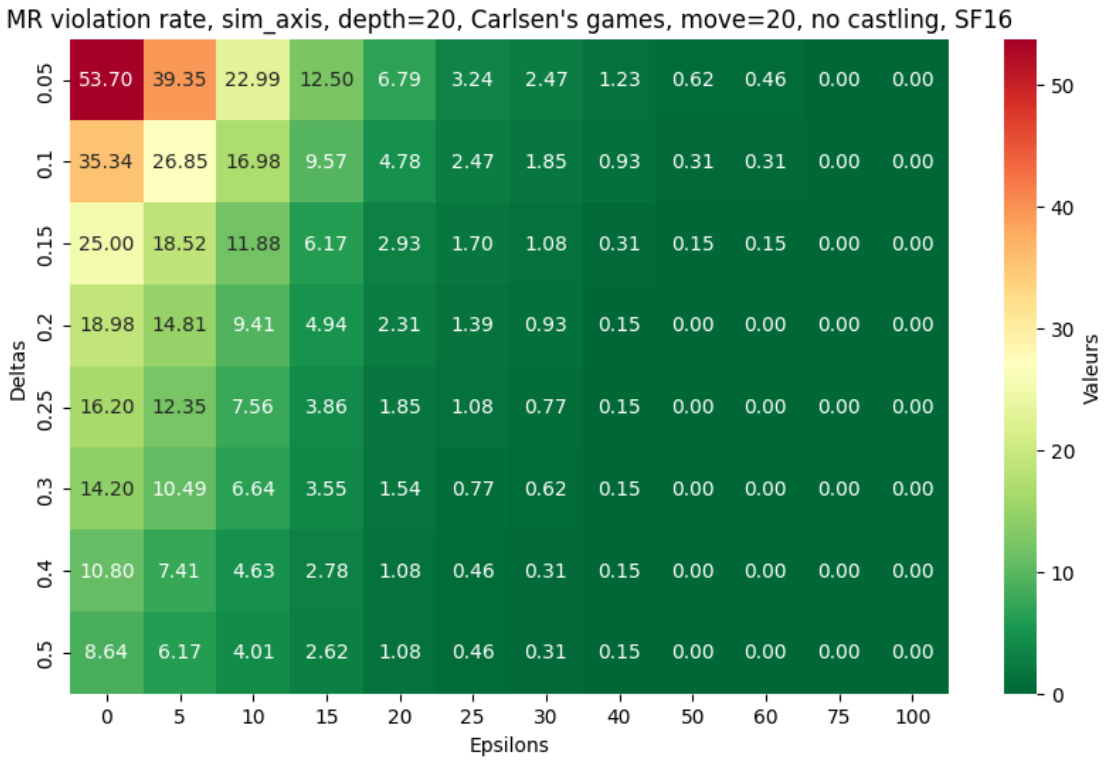
```
move = 20
```




**Carlsen's games, no castling available**

[661]:
```
path = os.path.join('reals','ev_Carlsen-20_nocastlingsim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs11620 = pickle.load(file)

print('move = 20')
tests(evs11620,1,20, ", Carlsen's games, move=20, no castling, SF16")
```

```
move = 20
```

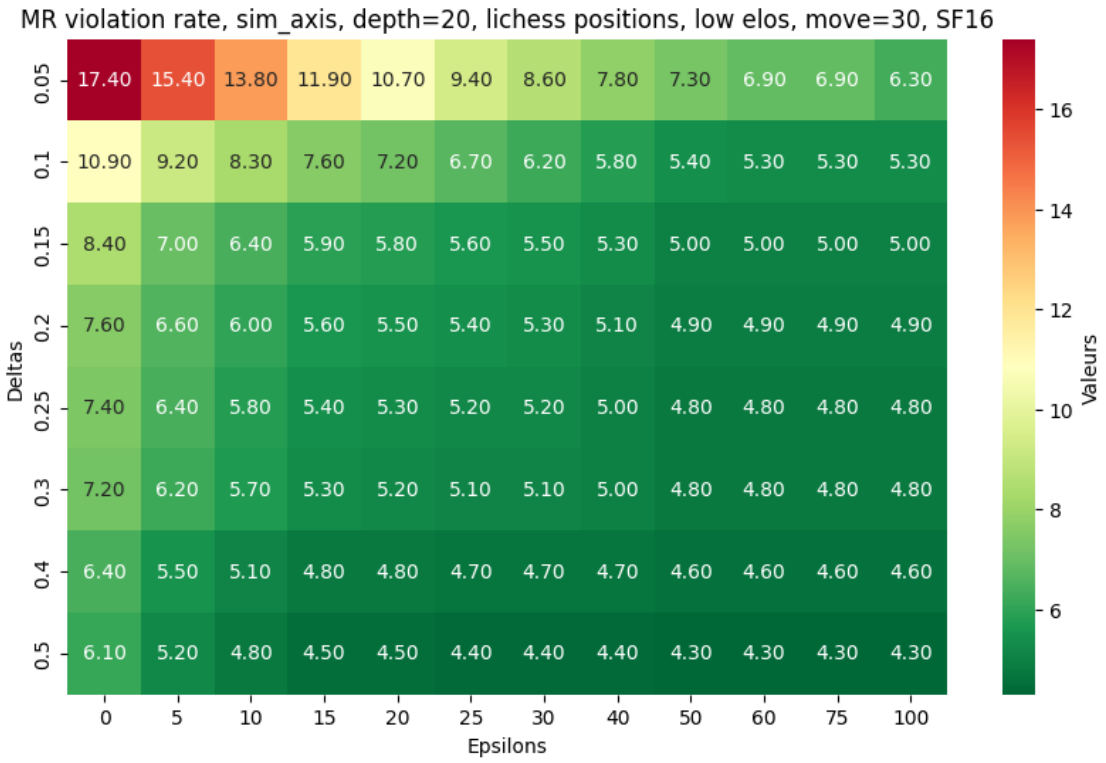



### Middle/Endgames (move=30)

### Lichess positions - 1000 to 1500 elo rating

[662]:
```
path = os.path.join('reals','ev_lichess1000-1500-30sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, low elos, move=30, SF16")
```

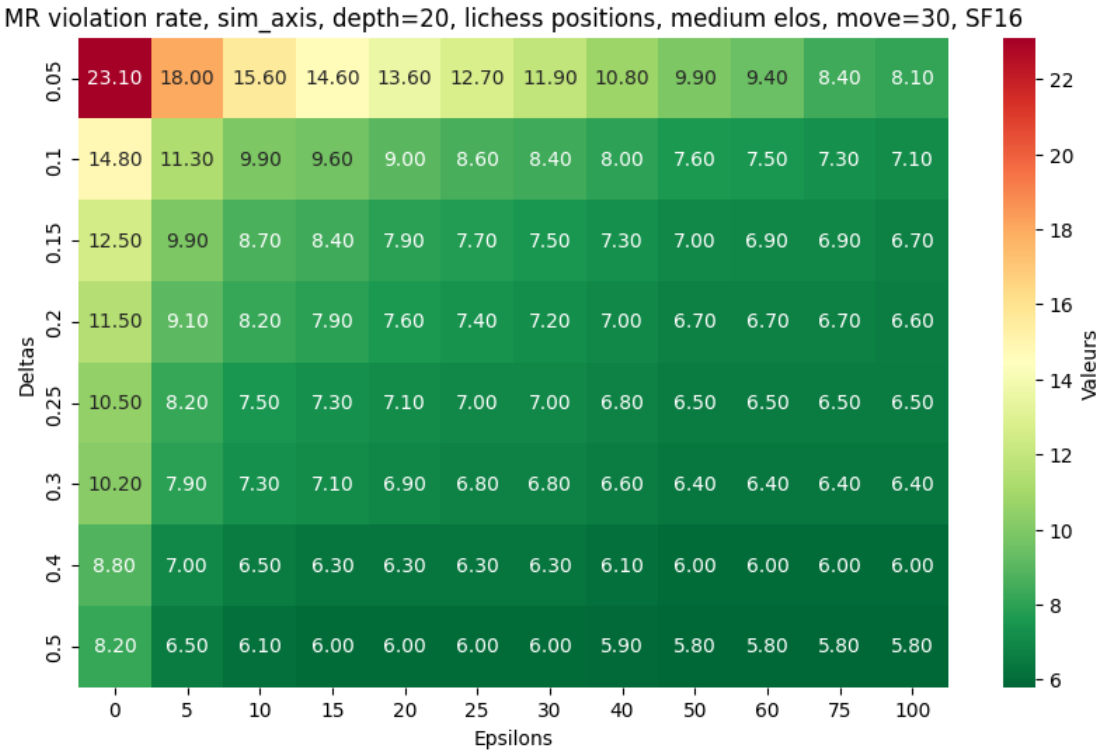
```
move = 30
```




**Lichess positions - 1500 to 2000 elo rating**

[663]:
```
path = os.path.join('reals','ev_lichess1500-2000-30sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, medium elos, move=30, SF16")
```

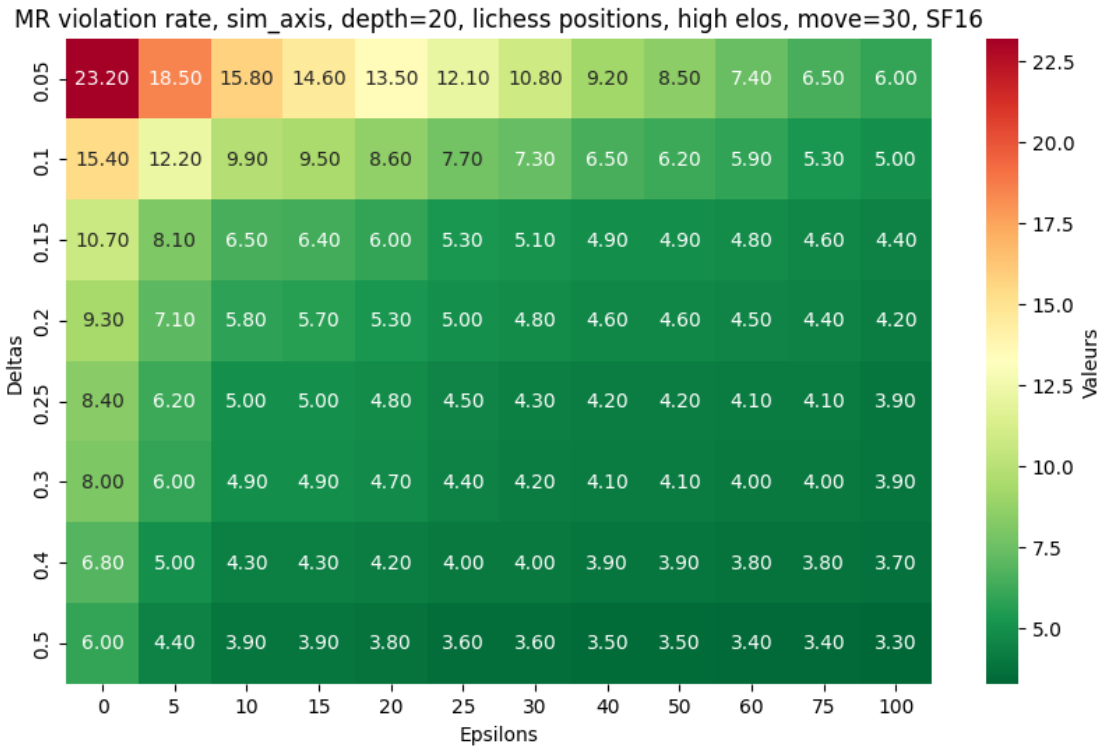
```
move = 30
```




**Lichess positions - 2000 to 2500 elo rating**

[664]:
```
path = os.path.join('reals','ev_lichess2000-2500-30sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, high elos, move=30, SF16")
```

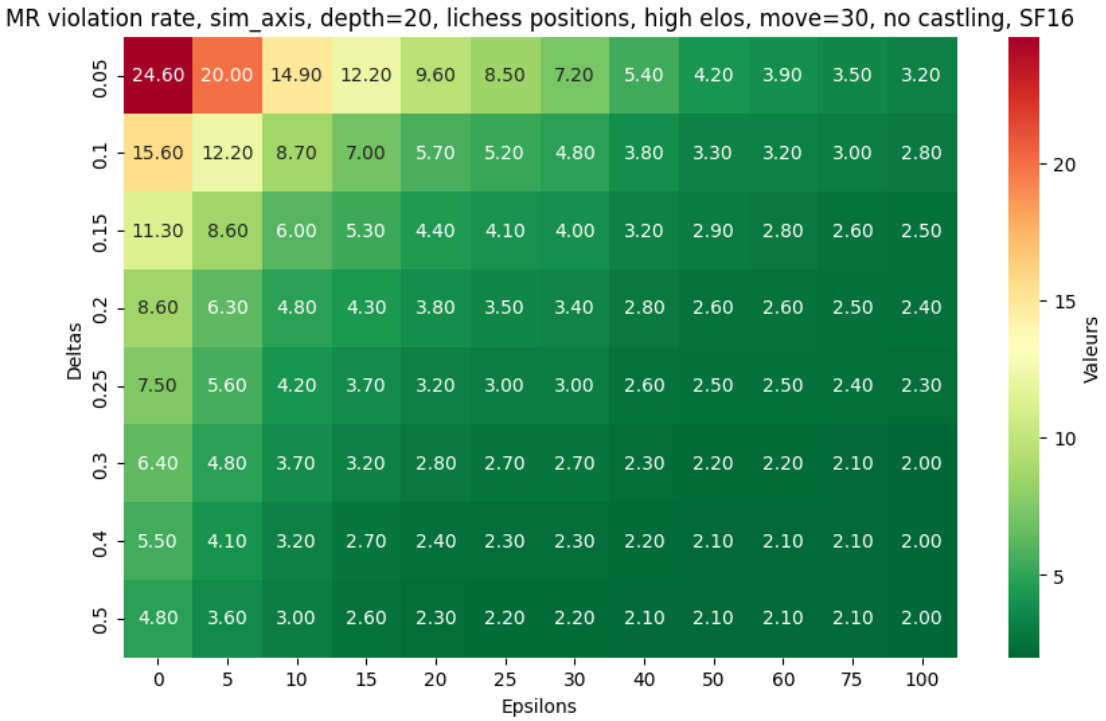
```
move = 30
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[665]:
```
path = os.path.join('reals','ev_lichess2000-2500-30_nocastlingsim_axis_d_20_v16.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, high elos, move=30, no castling, SF16")
```

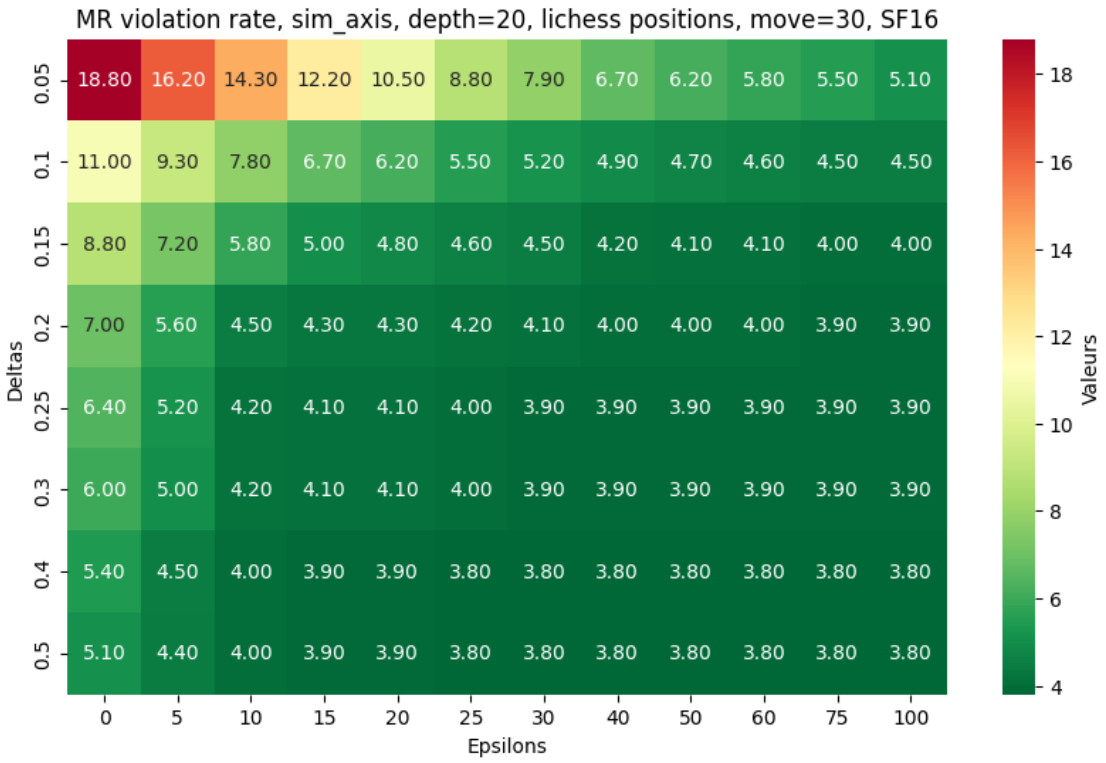
```
move = 30
```




**Lichess positions - All elos**

[666]:
```
path = os.path.join('reals','ev_lichessAllElos-30sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, move=30, SF16")
```

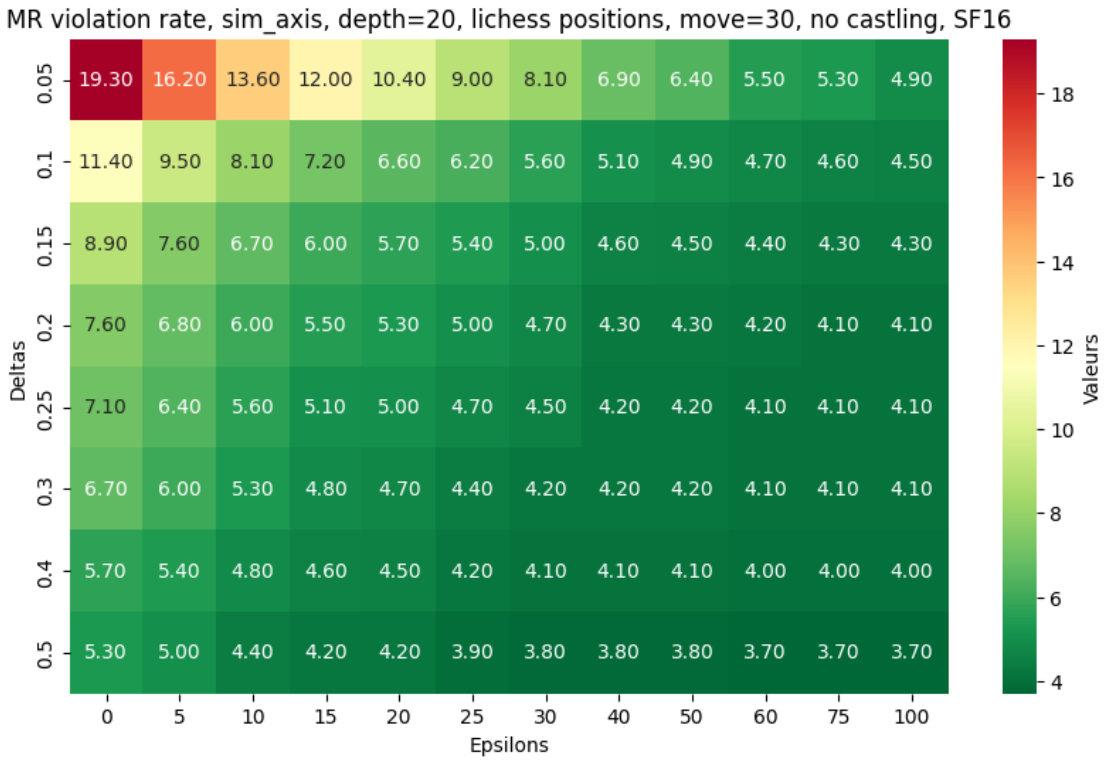
```
move = 30
```




**Lichess positions - All elos, no castling available**

[667]:
```
path = os.path.join('reals','ev_lichessAllElos-30_nocastlingsim_axis_d_20_v16.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", lichess positions, move=30, no castling, SF16")
```

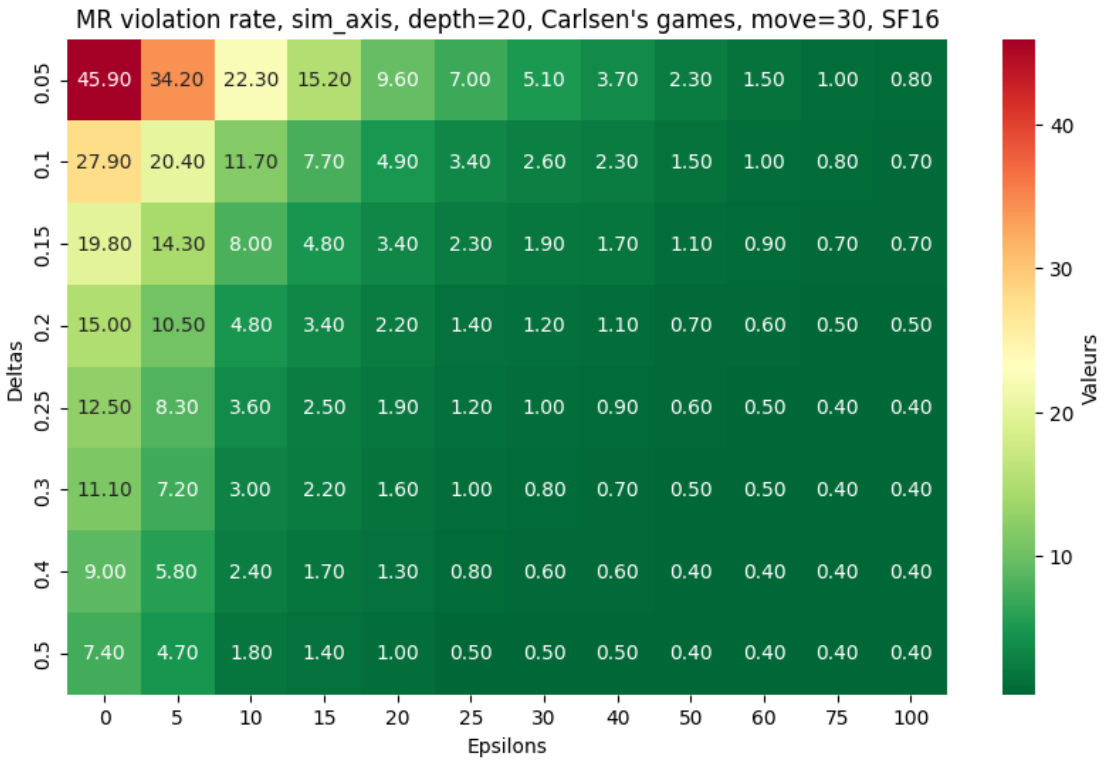
```
move = 30
```




### Carlsen's games

[668]:
```
path = os.path.join('reals','ev_Carlsen-30sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 30')
tests(evs,1,20, ", Carlsen's games, move=30, SF16")
```

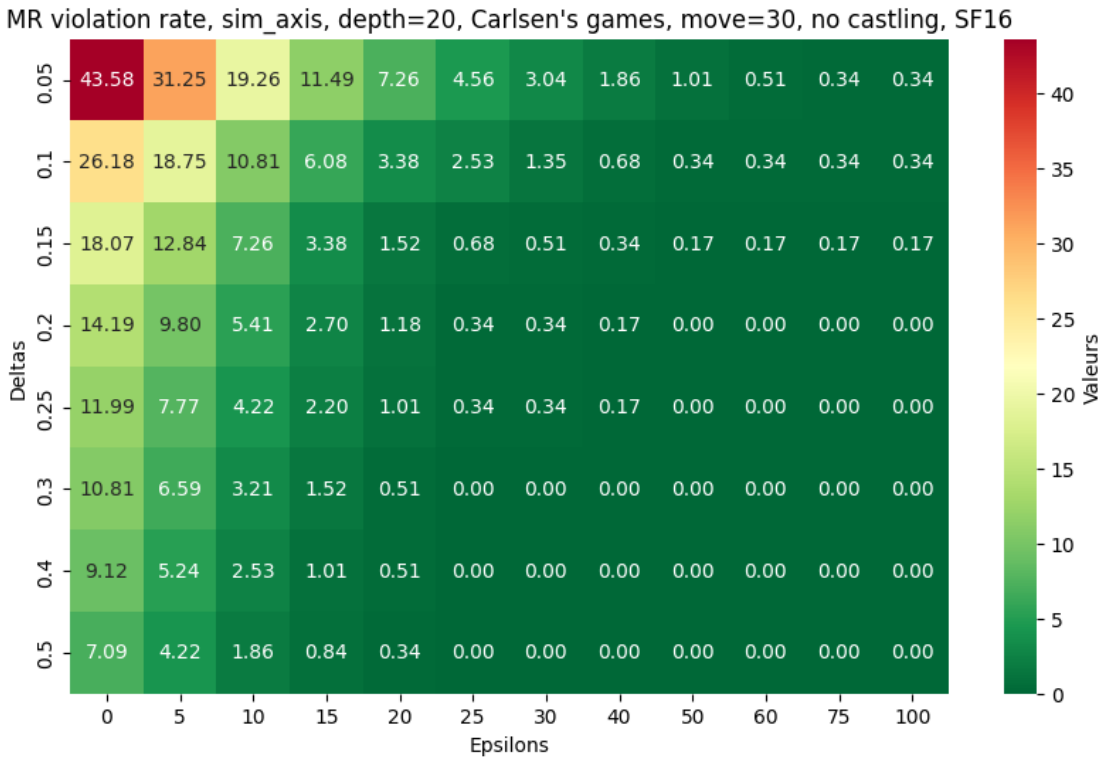
```
move = 30
```




**Carlsen's games, no castling available**

[669]:
```
path = os.path.join('reals','ev_Carlsen-30_nocastlingsim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs11630 = pickle.load(file)

print('move = 30')
tests(evs11630,1,20, ", Carlsen's games, move=30, no castling, SF16")
```

```
move = 30
```

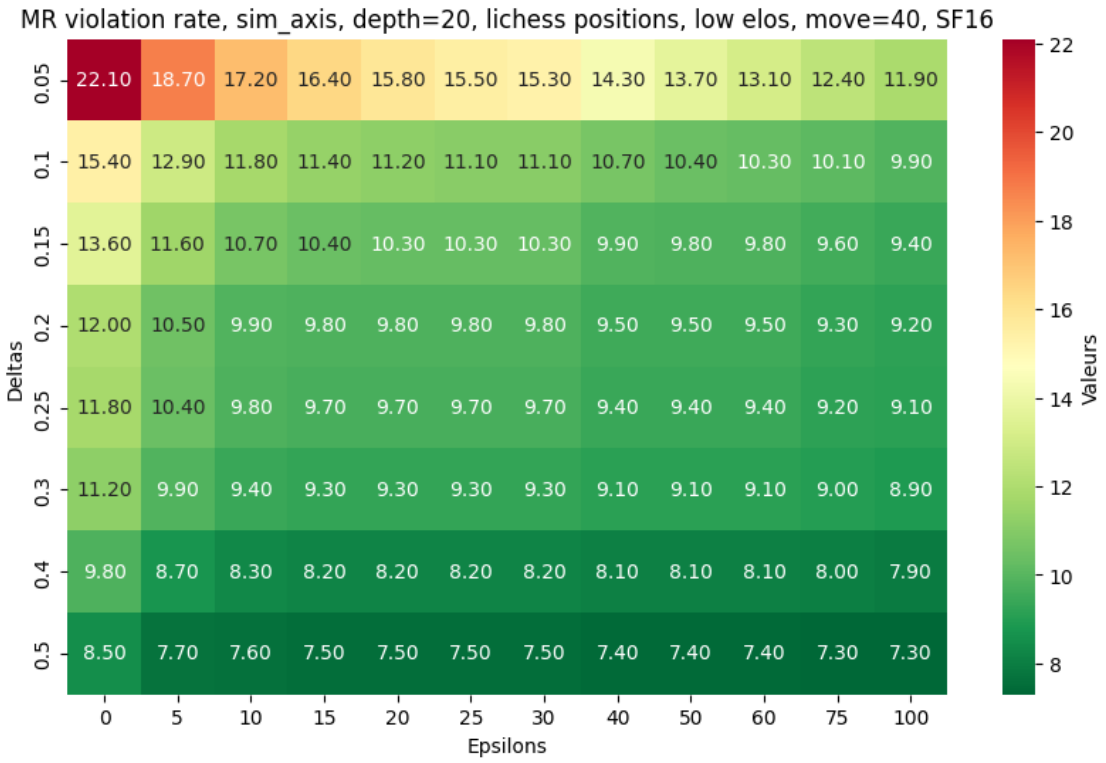



### Endgames (move=40)

### Lichess positions - 1000 to 1500 elo rating

[670]:
```
path = os.path.join('reals','ev_lichess1000-1500-40sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, low elos, move=40, SF16")
```

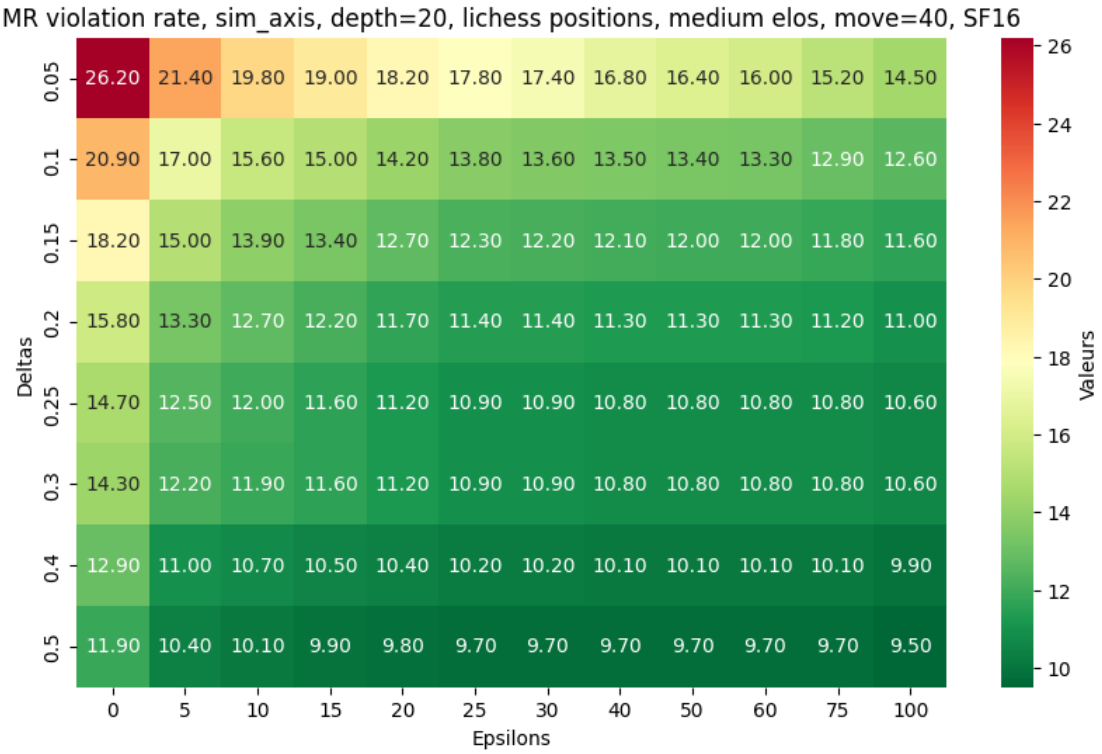
```
move = 40
```




**Lichess positions - 1500 to 2000 elo rating**

[671]:
```
path = os.path.join('reals','ev_lichess1500-2000-40sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, medium elos, move=40, SF16")
```

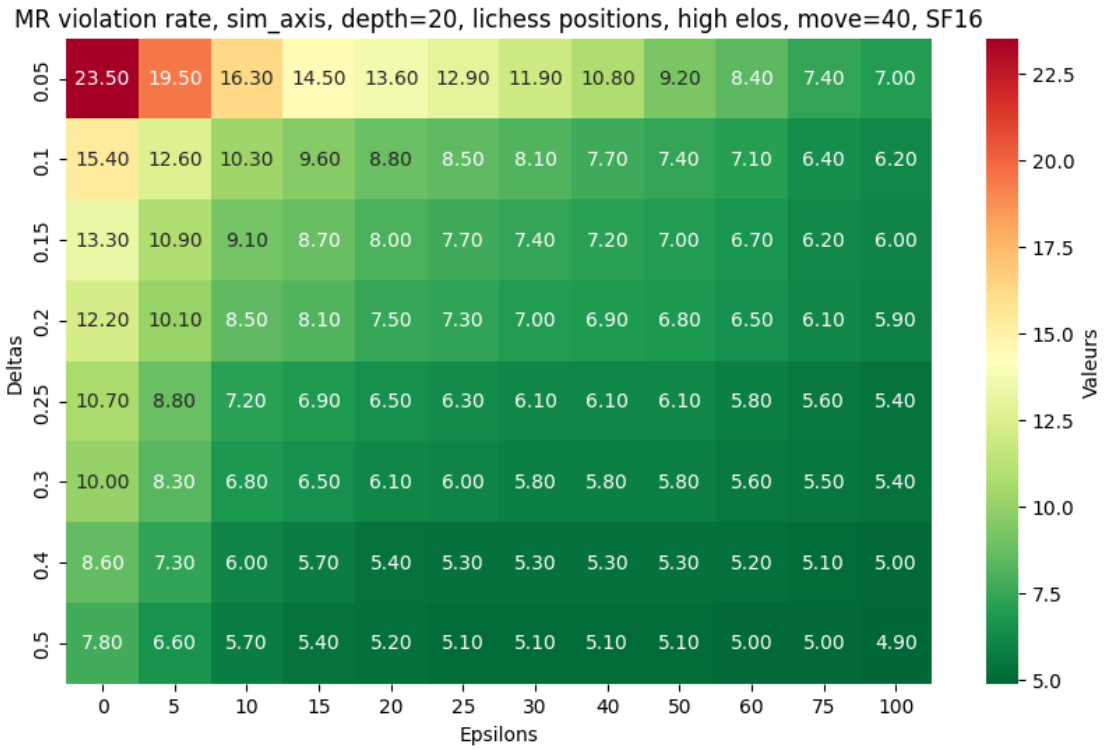
```
move = 40
```




**Lichess positions - 2000 to 2500 elo rating**

[672]:
```
path = os.path.join('reals','ev_lichess2000-2500-40sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, high elos, move=40, SF16")
```

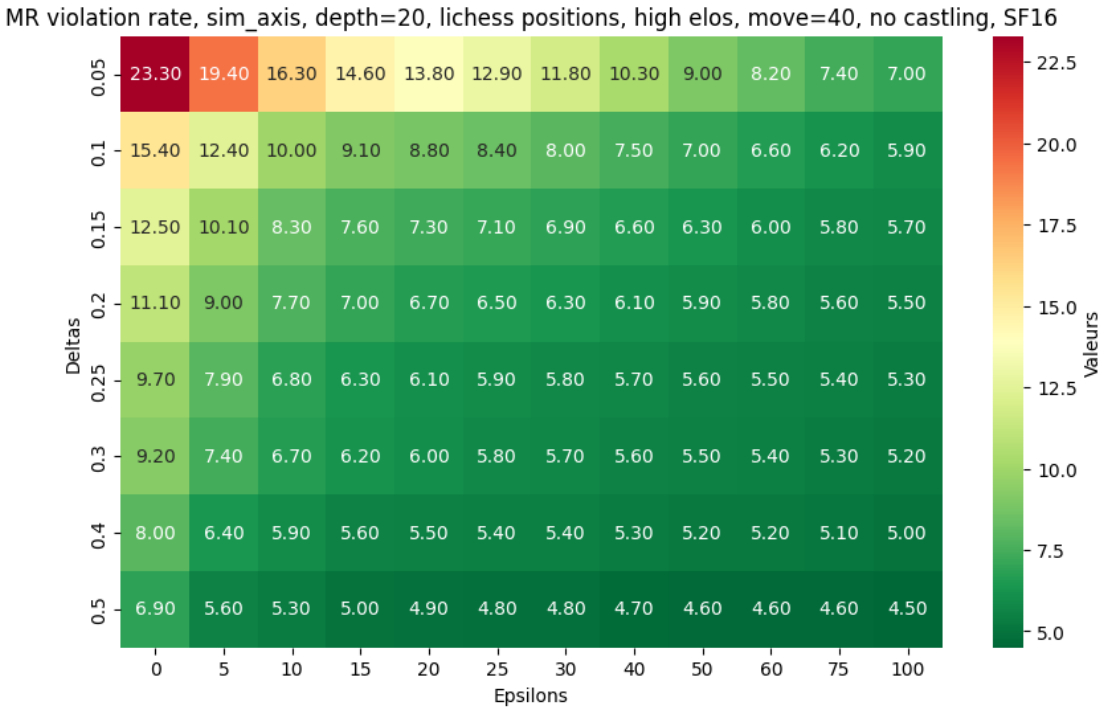
```
move = 40
```




**Lichess positions - 2000 to 2500 elo rating, no castling available**

[673]:
```
path = os.path.join('reals','ev_lichess2000-2500-40_nocastlingsim_axis_d_20_v16.
↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, high elos, move=40, no castling, SF16")
```

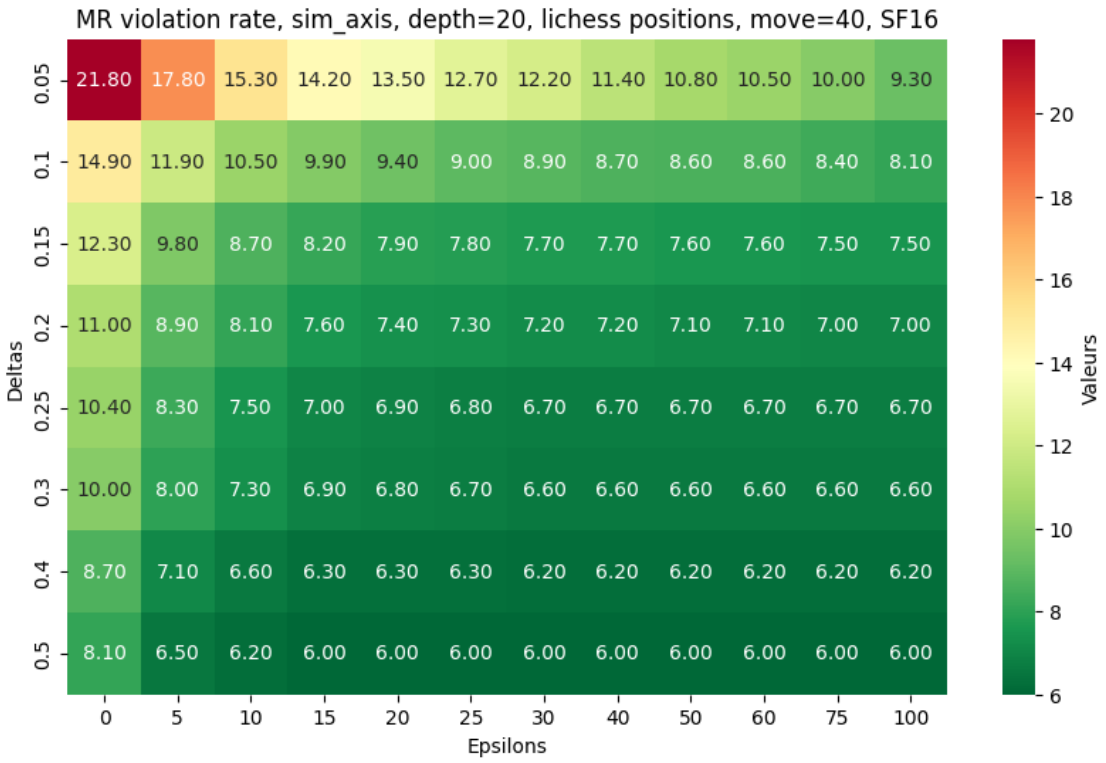
```
move = 40
```




### Lichess positions - All elos

[674]:
```
path = os.path.join('reals','ev_lichessAllElos-40sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, move=40, SF16")
```

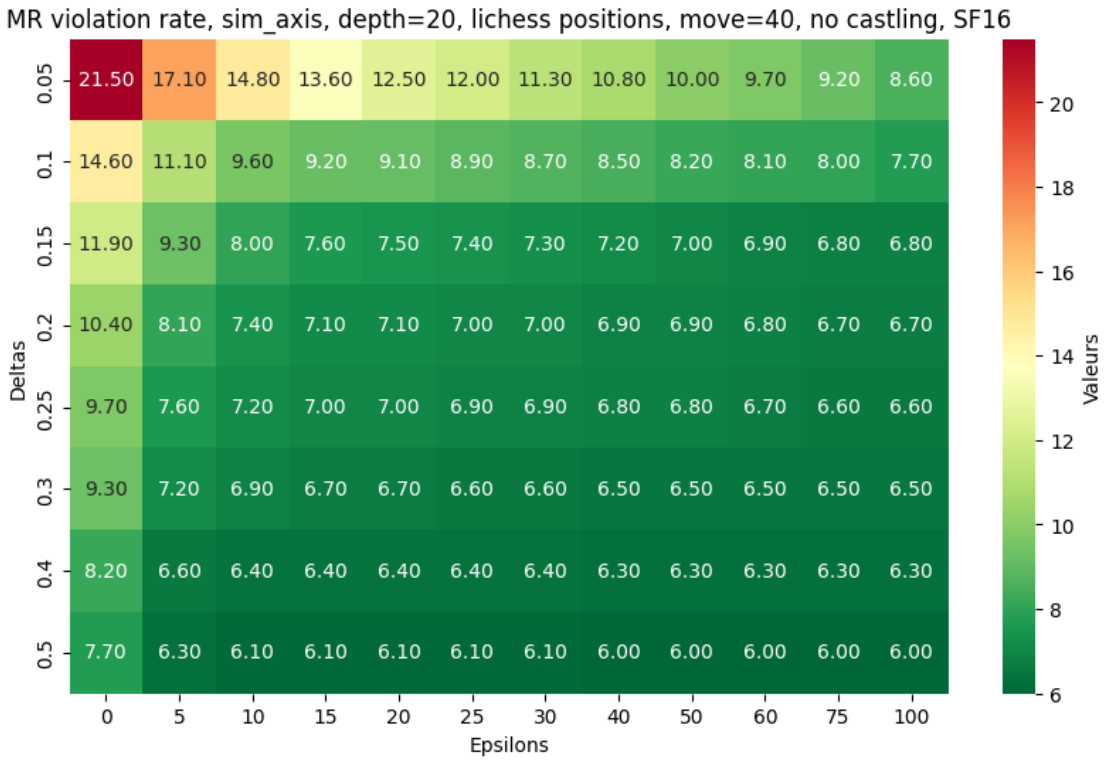
```
move = 40
```




**Lichess positions - All elos, no castling available**

[675]:
```
path = os.path.join('reals','ev_lichessAllElos-40_nocastlingsim_axis_d_20_v16.
  ↪pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", lichess positions, move=40, no castling, SF16")
```

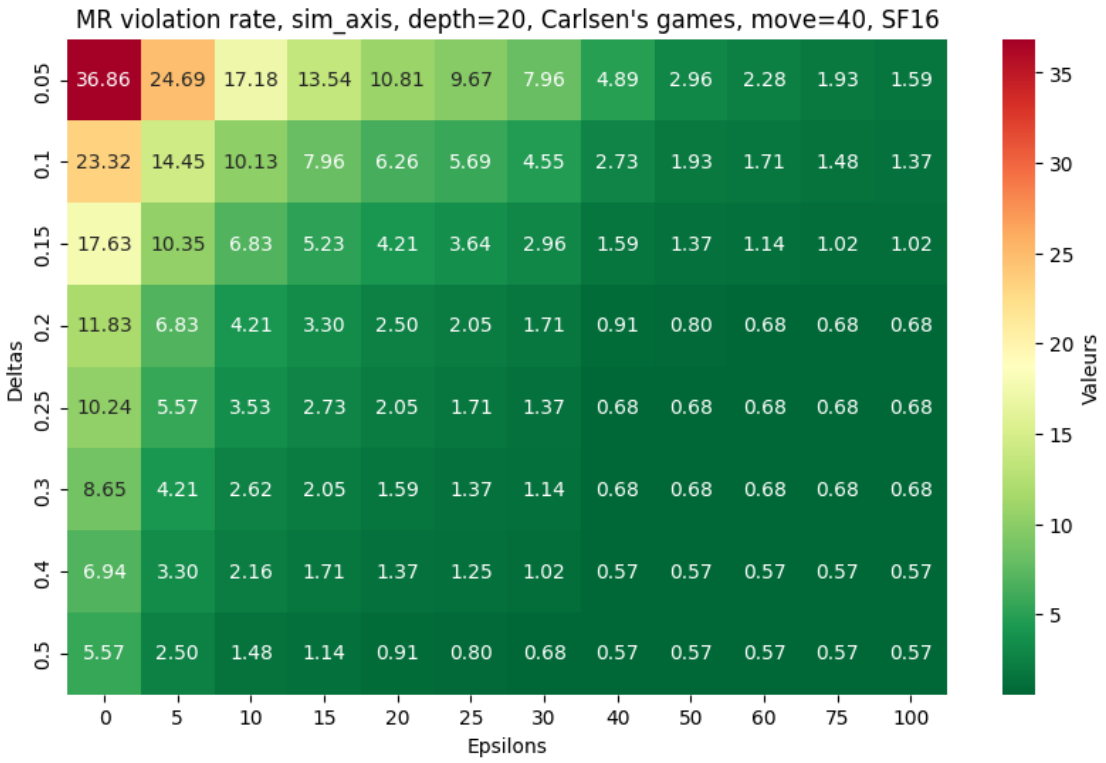
```
move = 40
```




### Carlsen's games

[676]:
```
path = os.path.join('reals','ev_Carlsen-40sim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, ", Carlsen's games, move=40, SF16")
```

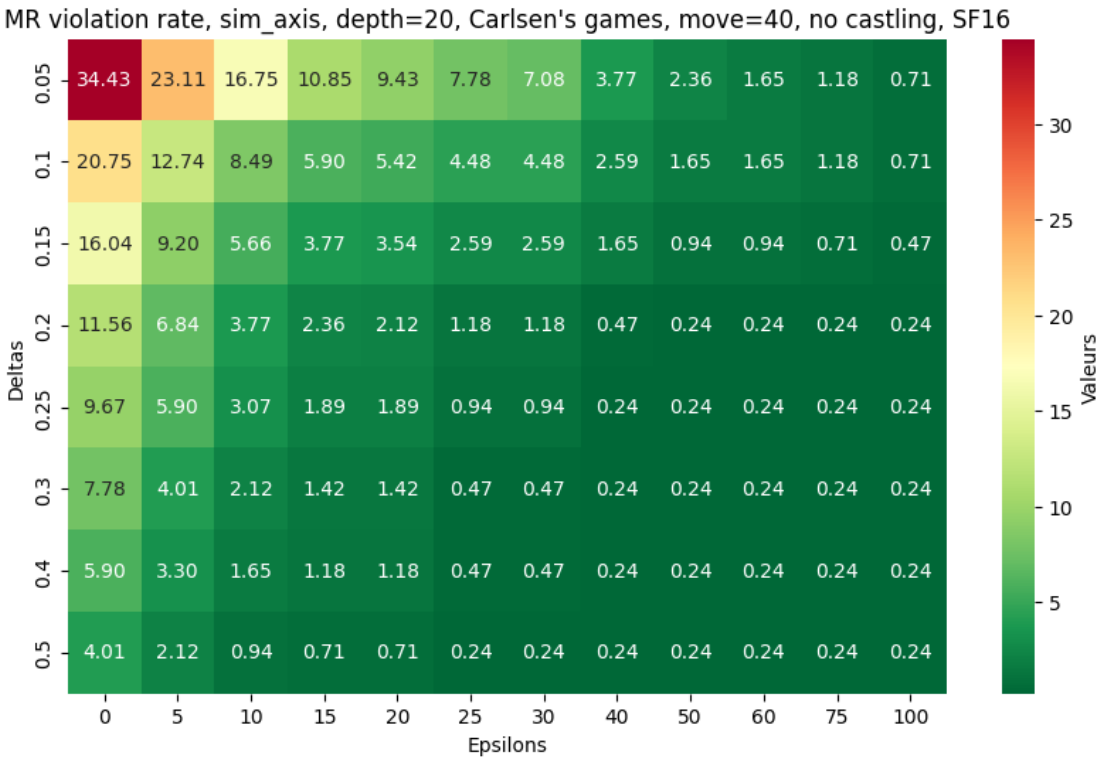
```
move = 40
```




**Carlsen's games, no castling available**

[677]:
```
path = os.path.join('reals','ev_Carlsen-40_nocastlingsim_axis_d_20_v16.pkl')
with open(path, 'rb') as file:
    evs11640 = pickle.load(file)

print('move = 40')
tests(evs11640,1,20, ", Carlsen's games, move=40, no castling, SF16")
```

```
move = 40
```

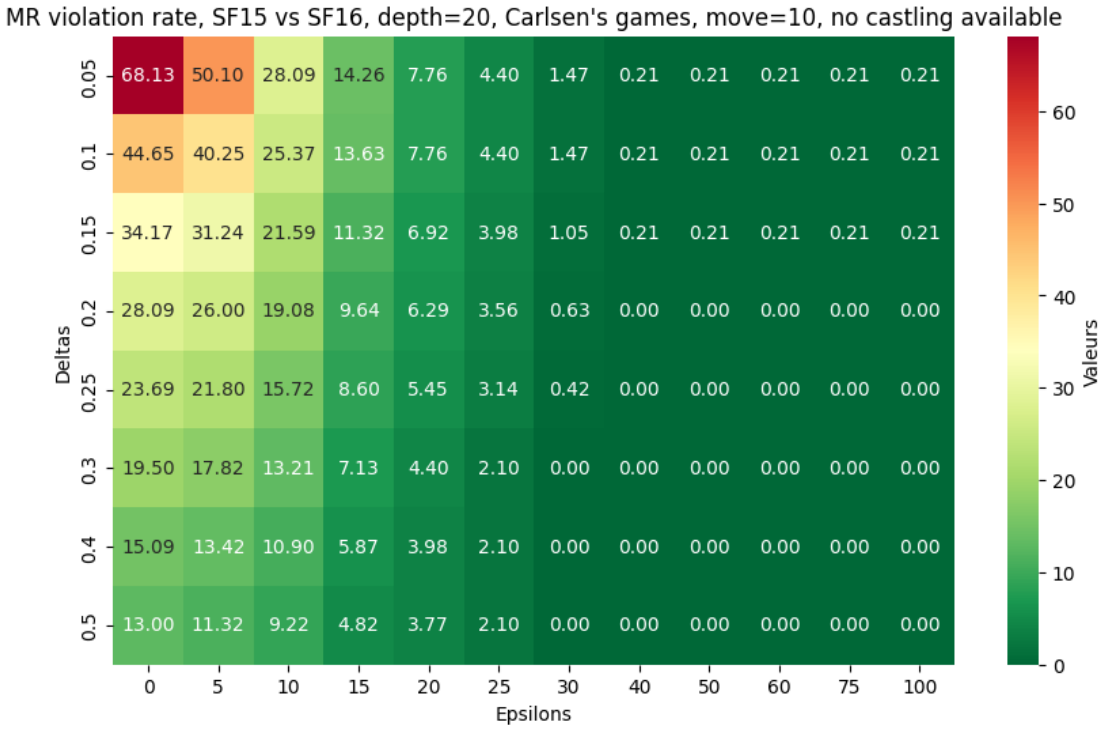



### 0.12.3 Differences between SF15 and SF16

For this part, we'll show the grids of gaps between SF15 and SF16, on Carlsen's games.

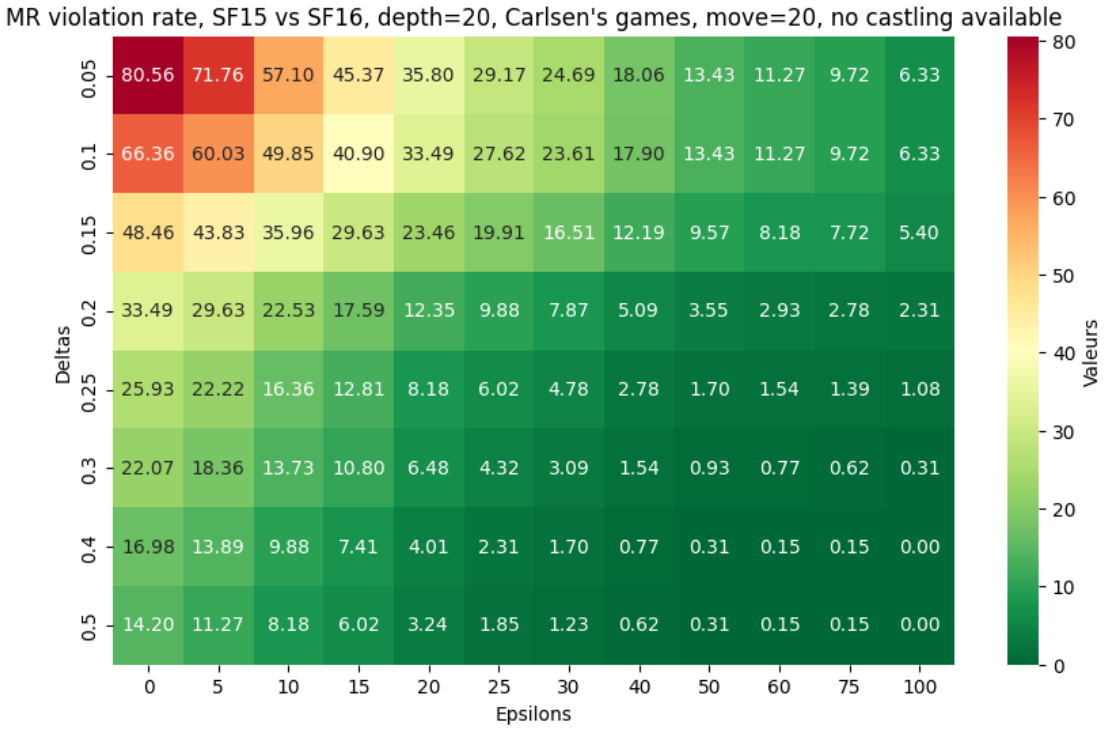
**move=10**

[679]:
```
tests(merge(evs11610,evs11510),5,20, ", Carlsen's games, move=10, no castling␣
↪available")
```



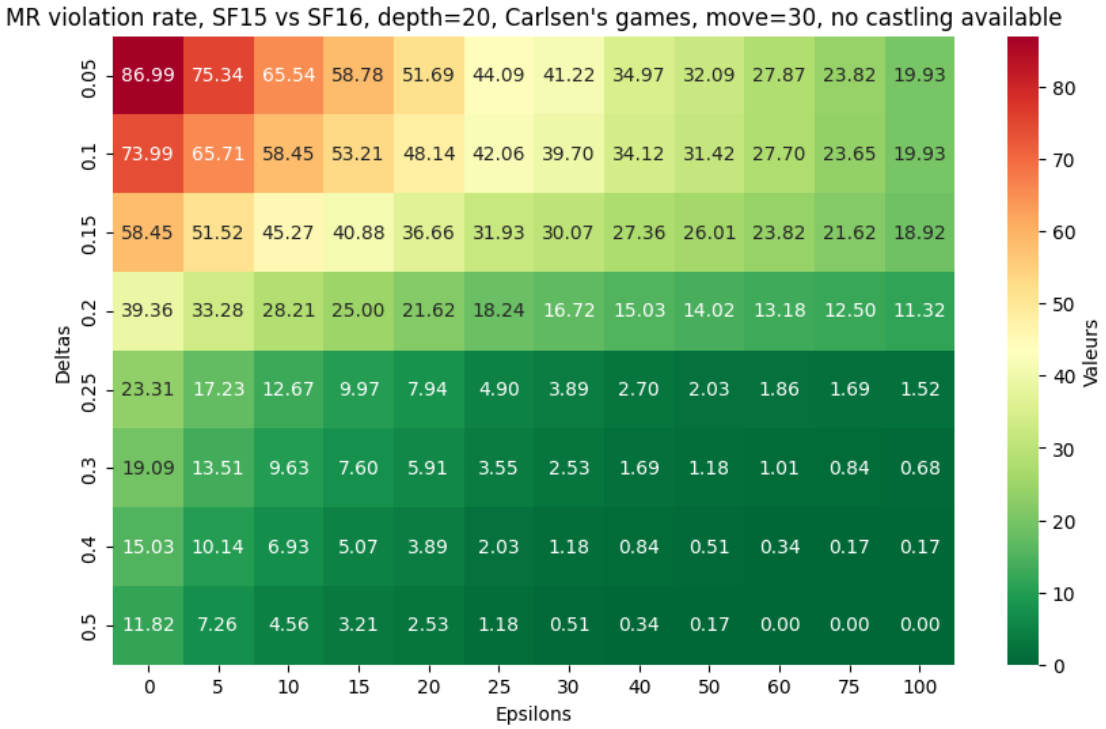

**move=20**

[680]:
```
tests(merge(evs11620,evs11520),5,20, ", Carlsen's games, move=20, no castling␣
↪available")
```



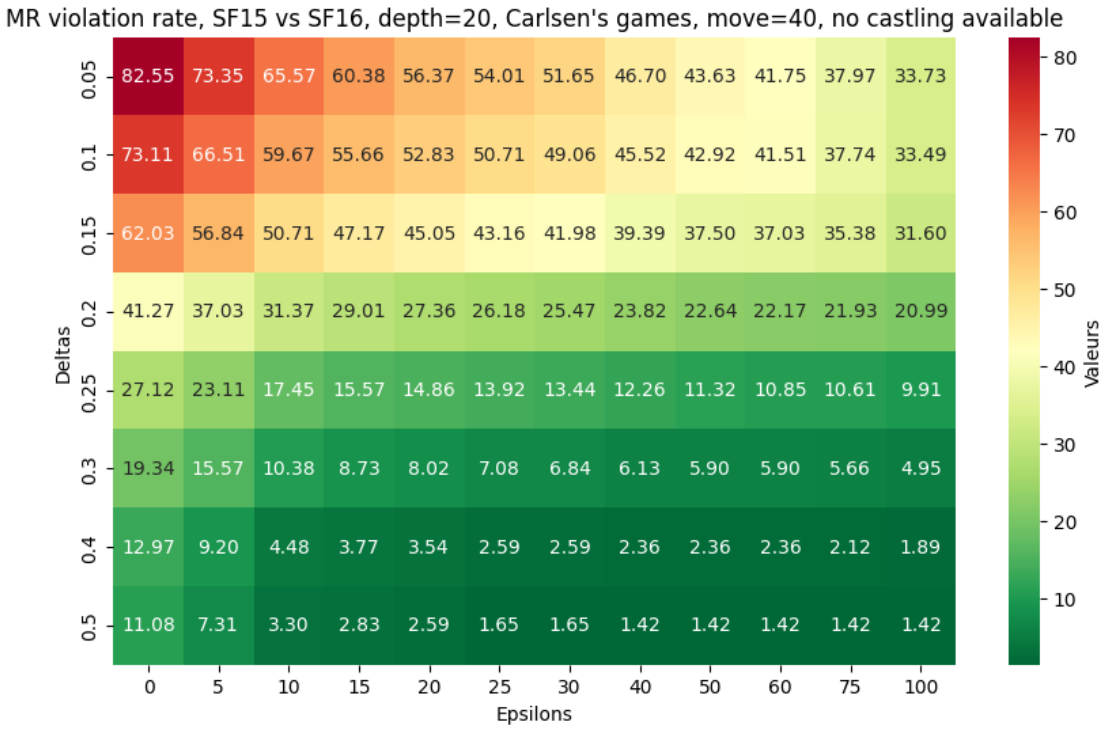

### move=30

[681]:
```
tests(merge(evs11630,evs11530),5,20, ", Carlsen's games, move=30, no castling␣
↪available")
```




**move=40**

[682]:
```
tests(merge(evs11640,evs11540),5,20, ", Carlsen's games, move=40, no castling␣
↪available")
```




**Comments on SF15 vs SF16** As we can see, SF16 is slightly better and SF15 and SF16 tend to have bigger gaps on endgame positions.

### 0.12.4 Analysis on some gaps

We can observe that Stockfish tends to violate MRs more frequently in endgame positions. This is due to the higher rate of mate-positions where Stockfish doesn't return the same mate value when the position is mutated. Actually, it may be interesting to try what happens if we consider that as long as the mate is for the same side on both positions, MRs are not violated.

Editing MR_equi as shown below:

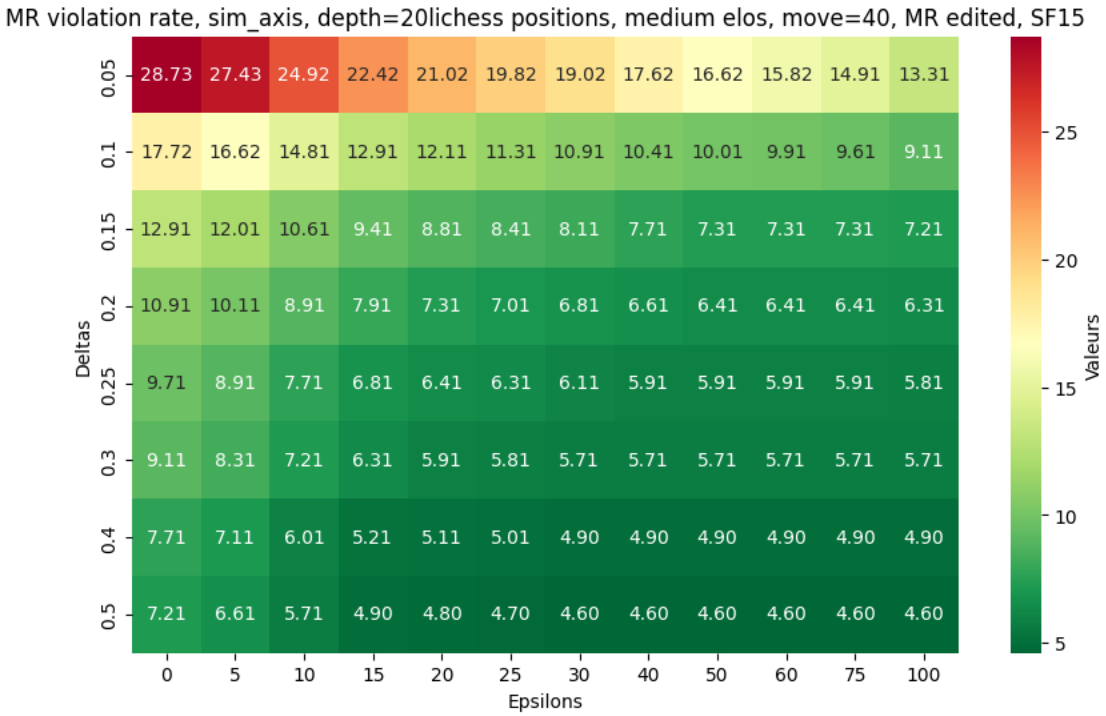
[234]:
```
#for sim_axis and sim_diag
def MR_equi(o1, o2, delta, epsilon):
    final = False
    if o1.get('type') != o2.get('type'):
        final = False
    elif o1.get('type') == o2.get('type') == 'mate' and o1.get('value')*o2.
 ↪get('value')<0:
        final = False
    elif o1.get('type') == o2.get('type') == 'cp' and dif1(o1.get('value'), o2.
 ↪get('value')) > delta and dif2(
            o1.get('value'), o2.get('value')) >= epsilon:
        final = False
```

```
    else:
        final = True
    return final
```

**Move 40, Lichess positions - 1500 to 2000 elo rating** This grid originally showed more than 10% of failure.

[683]:
```
path = os.path.join('reals','ev_lichess2000-2500-40sim_axis_d_20.pkl')
with open(path, 'rb') as file:
    evs = pickle.load(file)

print('move = 40')
tests(evs,1,20, "lichess positions, medium elos, move=40, MR edited, SF15")
```

```
move = 40
```




The difference is due to the relatively high percentage of mate positions.

[236]:
```
print("Mates proportion : ", len(split_mate_cp(evs)[1])/
  ↪(len(split_mate_cp(evs)[0])+len(split_mate_cp(evs)[1])))
print('Mates failure rate : ',100-MR(split_mate_cp(evs)[1],1,1,1),'%')
```

```
Mates proportion :  0.13713713713713713
Mates failure rate :  12.408759124087581 %
```

We'll now print evaluations as a function of depth on biggest gaps.

**sim_mirror**

**Carlsen positions, move 10**

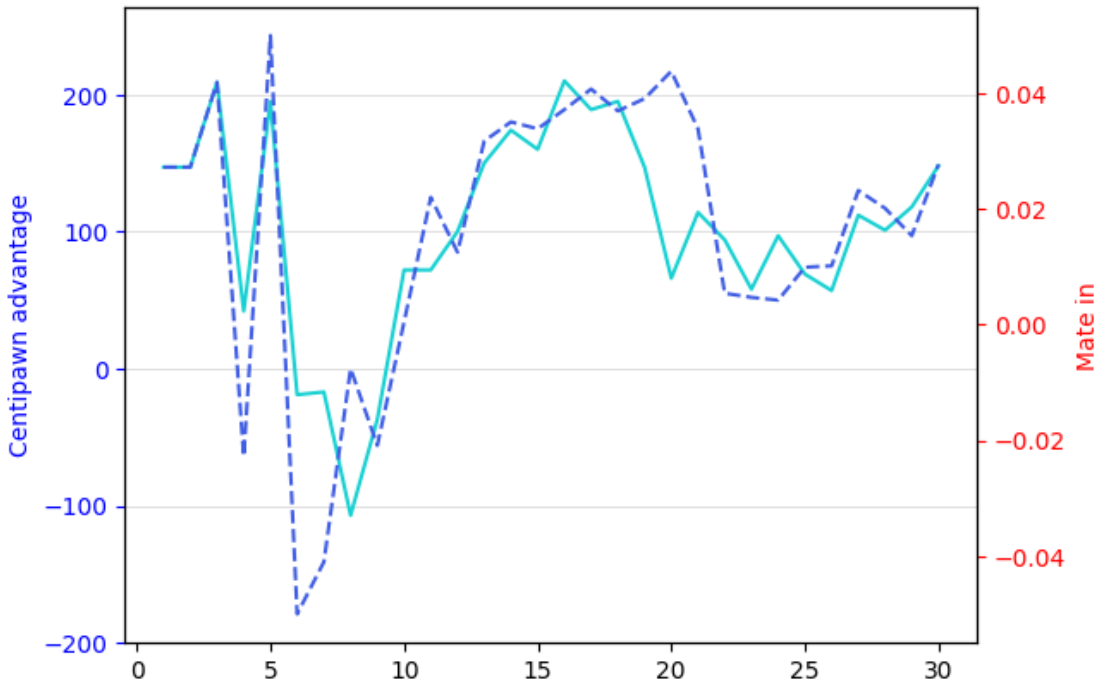
[237]:
```
carlsen10 = 'r2qkb1r/pp2p2p/n4pN1/1Npn3Q/8/8/PPPP1PPP/R1B1K2R b'

show_pos([carlsen10],300)
print(evaluationdouble(carlsen10,sim_mirror(carlsen10),50000,20))
```

```
<IPython.core.display.HTML object>
```

```
({'type': 'cp', 'value': 66}, {'type': 'cp', 'value': -217})
```

[238]:
```
chemin = os.path.join('plotevas', 'calsen10.pkl')
with open(chemin, 'rb') as fichier:
    carlsen10p = pickle.load(fichier)

plotevas(carlsen10p[0],carlsen10p[1],carlsen10p[2], 0)
```

```
MR verified at depth =  [2, 3, 5, 9, 12, 13, 14, 15, 16, 17, 18, 19, 21, 23, 25,
26, 27, 28, 29, 30]
```




**sim_axis**

**Lichess positions - 1500 to 2000 elo rating, move 40**

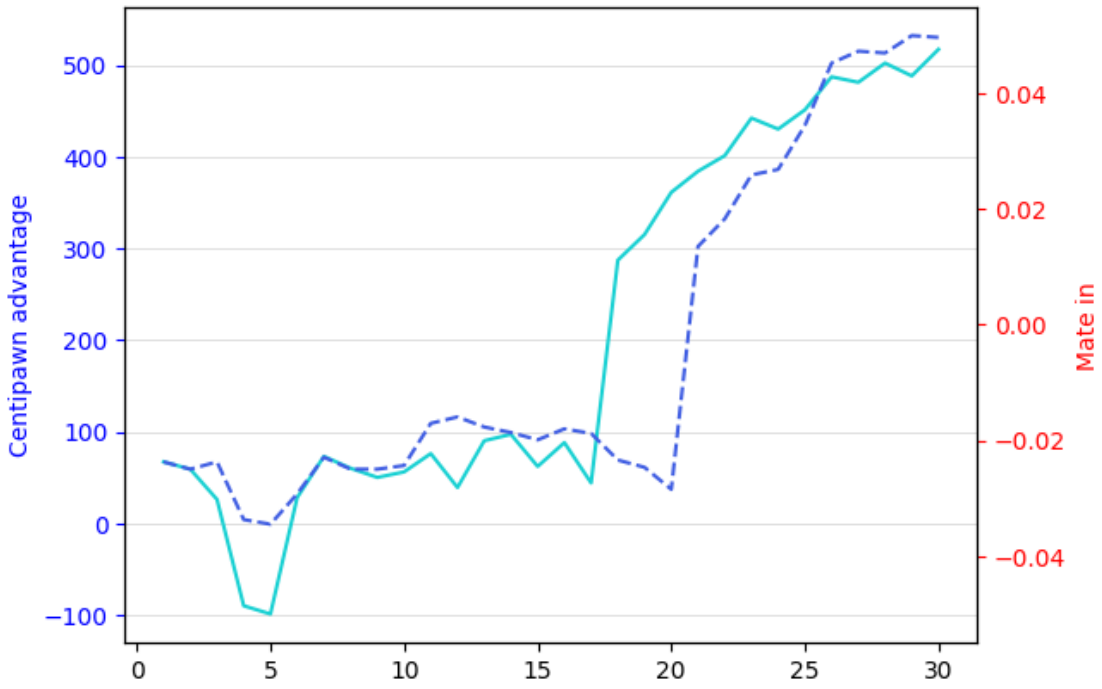
[239]:
```
pos = '8/1p5p/p3k3/4p1P1/P2bP3/7N/2p4P/2B4K b'

show_pos([pos],300)
print(evaluationdouble(pos,sim_axis(pos),50000,20))
```

```
<IPython.core.display.HTML object>
```

```
({'type': 'cp', 'value': 361}, {'type': 'cp', 'value': 37})
```

[728]:
```
chemin = os.path.join('plotevas', 'L152040.pkl')
with open(chemin, 'rb') as fichier:
    l152040 = pickle.load(fichier)

plotevas(l152040[0],l152040[1],l152040[2], 1)
```

```
MR verified at depth =  [2, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 21, 22, 23, 24,
25, 26, 27, 28, 29, 30]
```




[729]:
```
sim_axis(pos)
```

[729]:
```
'8/p5p1/3k3p/1P1p4/3Pb2P/N7/P4p2/K4B2 b'
```

[240]:
```
sim_axis('1N5k/3Kb2q/1NP3p1/1R4B1/3R4/1B6/8/n3Q3 w')
```

[240]:
```
'k5N1/q2bK3/1p3PN1/1B4R1/4R3/6B1/8/3Q3n w'
```

[713]:
```
with open('massplotevas/evas_axis_1.pkl','rb') as fichier:
    loaded = pickle.load(fichier)
```

```
[2, 3, 4, 7, 8, 10, 11, 12, 13, 14, 15]
```

[714]:
```
tableau = [0] * 25
for k in range(len(loaded)):
    for l in loaded[k][2]:
        if l<len(tableau):
            tableau[l]+=1
tableau
```

[714]:
```
[0,
 0,
 100,
 91,
 83,
 67,
 71,
 69,
 70,
 72,
 74,
 85,
 78,
 83,
 88,
 88,
 86,
 87,
 87,
 92,
 89,
 92,
 96,
 96,
 96]
```

[ ]:
```

```