

Scalable Psychological Momentum Forecasting in Esports

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Psychological Momentum

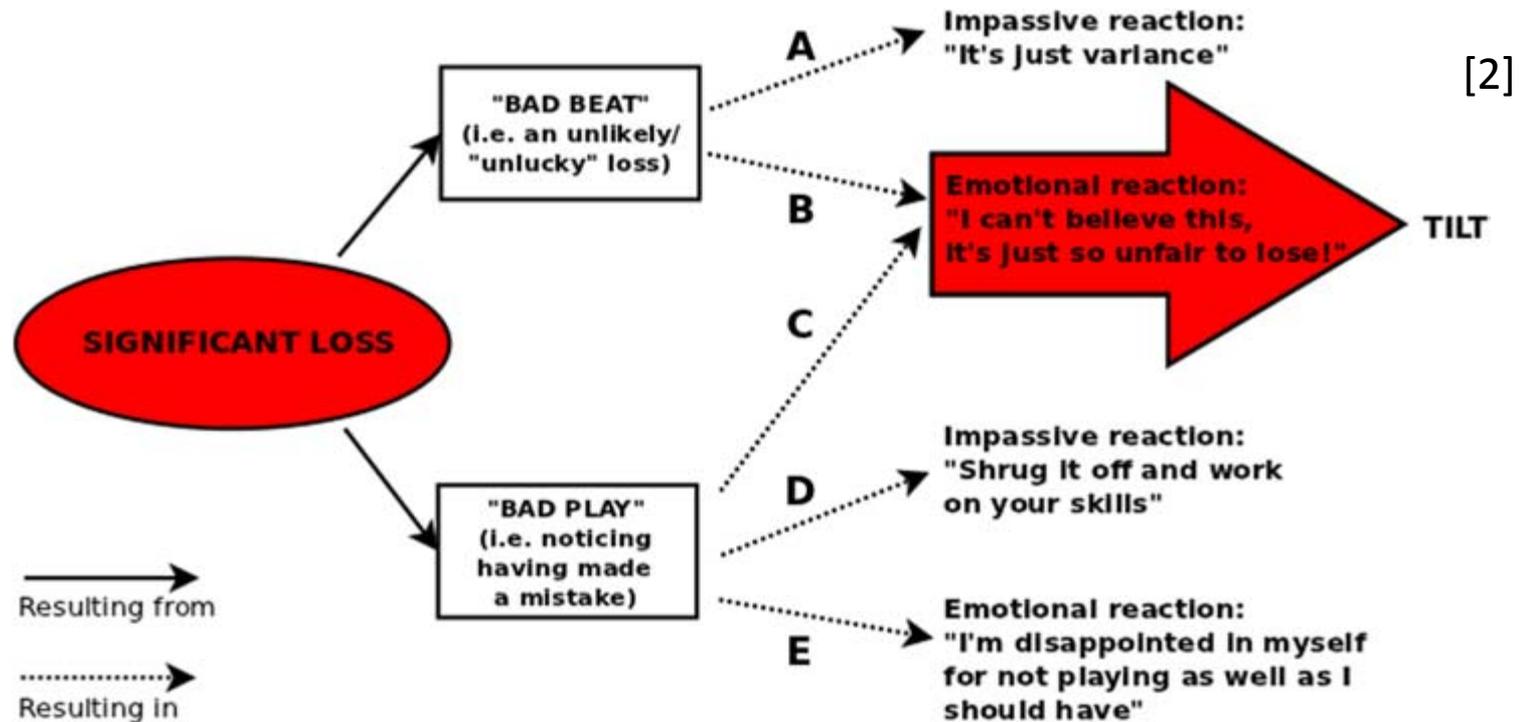
- The **transient** tendency of an athlete or team to repeat their most recent performances; effective skill deviation
- Sources: cognitive, affective and/or physiological; often dependent on external **perceptions**
- Wide variation in effect size, duration and *manifestation*:
 - ‘Hot hands’ in basketball (higher shot success rate after a streak)
 - ‘Flow states’ in elite sports (e.g., Formula One) and elite musicians
 - Workplace synergy and team motivation
 - Being ‘in the zone’ more generally; **high-performance** environments

Tilt

- A common form of *negative* momentum in **competitive** and/or **social** task environments; a cognitive-emotional bias
 - Causes 'downward spiraling' – difficult to recover
1. An evolutionary **self/ego-preservation** strategy in social contexts perceived as threatening (i.e., impulsivity)
 2. Noise distribution blindness causing unavoidable overconfidence when integrating multiple discordant sources of **imperfect information** [1]
 3. **Synaptic fatigue** (over-repetition)
- Leads to loss in rank (status), chasing those losses, psychological distress

[1] Human noise blindness drives suboptimal cognitive inference, Santiago Herce Castañón, Dan Bang, Rani Moran, Jacqueline Ding, Tobias Egner, and Christopher Summerfield. 2018

Aetiology of Tilt

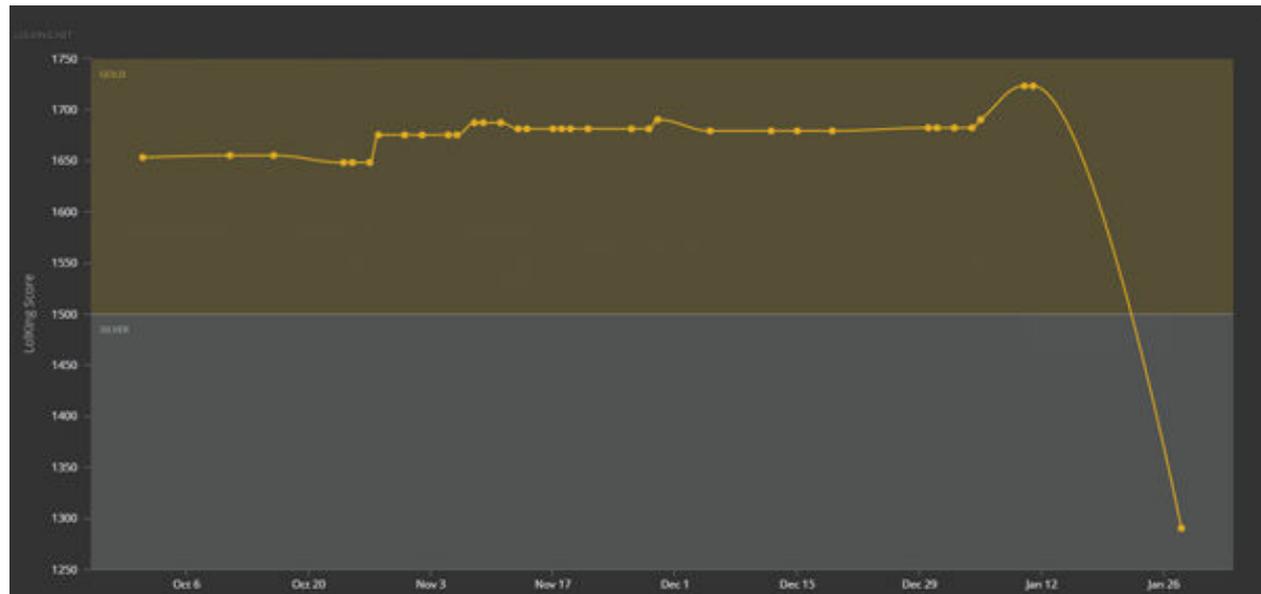


[2] Jussi Palomäki, Michael Laakasuo, and Mikko Salmela. 2013. 'This is just so unfair!': A qualitative analysis of loss-induced emotions and tilting in on-line poker. *International Gambling Studies* 13, 2 (2013), 255–270.

Aftermath of Untreated Tilt

Following feelings of **dissociation** and **moral indignation**:

- Psychological **distress**
 - Depression
 - Anxiety
 - Sleep problems
- Loss of time: many hours, days or even weeks of in-game **progress lost**



Recovery Strategies

[3]

- Taking a break
 - Mindfulness
 - Socialisation
 - ✓ Forming teams with friends, rather than strangers -> **consolation**, etc.
 - ✓ Relating with **mutual experiences** on gaming forums etc.
 - Skill-matched friends not always available; a **compromise**
 - Less emphasis on **personal development**
 - Can backfire... friendships **stressed**
- Still reliant on strong independent self-awareness and control

Tilt Detection & Notification

- Existing method: based on a webcam and facial recognition in poker [4]
 - Interesting, but **low applicability**
- Hire a coach, to either watch your gameplay in real-time, or retrospectively annotate performance histories
- Something more **accessible/practical**?

[4] Xingjie Wei, Jussi Palomaki, Je Yan, and Peter Robinson. 2016. The Science and Detection of Tilting. In Proceedings of the 2016 ACM on International Conference on Multimedia Retrieval. ACM, 79–86.

Automatic Data-driven Detection

↑
new
session

- Is it possible?
Case study: League of Legends
match performance summaries

↑
time

15.4% win rate (vs. 47.8% season avg.)

0.674 KDA ratio (vs. 2.13 season avg.)

Zero breaks between matches

Ranked Solo 12 minutes ago Defeat 28m 12s	Jhin	7 / 9 / 12 2.11:1 KDA	Level12 114 (4) CS P/Kill 59% Tier Average Gold 3	Kevin... Not Clean leeddr Jun Hyos... PhD Mun... AndyEsque Altered TL...
Ranked Solo an hour ago Defeat 29m 38s	Sona	1 / 6 / 11 2.00:1 KDA	Level12 12 (0.4) CS P/Kill 41% Tier Average Gold 3	Hotsfordayz MSG ME ... NekoShino DaBlackT... Mr 100 Jun Hyos...
Ranked Solo an hour ago Defeat 22m 5s	Lux	0 / 10 / 5 0.50:1 KDA	Level9 6 (0.3) CS P/Kill 45% Tier Average Gold 3	PualLIN ... niklaus222 Hawkeye... MRkingd... jm evin Korea T P... AD Lovec... SORÅ worlds be... Jun Hyos...
Ranked Solo 2 hours ago Defeat 25m 36s	Nautilus	0 / 10 / 7 0.70:1 KDA	Level10 35 (1.4) CS P/Kill 32% Tier Average Gold 3	WE xiaolizi CuteCatJ... Justinsan... mrr dooky... Azoth112 nTwFRyvo... Stan wawa ImHereTo... Ryuseiken Jun Hyos...
Ranked Solo a day ago Victory 30m 11s	Miss Fortune	6 / 7 / 6 1.71:1 KDA	Level13 139 (4.6) CS P/Kill 50% Tier Average Gold 3	YouMadC... twistedM... ad222 Limits of ... Dokidoki JK Riet Rovi... Garreywill... Jun Hyos... KhanStor... Ferienne
Ranked Solo a day ago Defeat 24m 39s	Leona	2 / 8 / 6 1.00:1 KDA	Level10 26 (1.1) CS P/Kill 57% Tier Average Gold 3	FalthinGod Liu Qing ... Miss Teri... Disordersot Kenshins... Chen Xia... Smily YvonneeO yaboyng Jun Hyos...
Ranked Solo a day ago Defeat 24m 0s	Nautilus	0 / 6 / 8 1.33:1 KDA	Level10 36 (1.5) CS P/Kill 62% Tier Average Gold 3	Chippy18 dannyyurp NorthSR Verixs Beccoy SurfarKidll Austin Mrs Poop... Warriors ... Jun Hyos...
Ranked Solo a day ago Victory 20m 29s	Singed	0 / 4 / 6 1.50:1 KDA	Level10 86 (4.2) CS P/Kill 29% Tier Average Gold 3	Jun Hyos... berniely LilPorom... Sir Salmon7 Melodies Boyka0415 BEASIST Mystic Ni... Chiroyo Dlite96
Ranked Solo a day ago Defeat 19m 5s	Teemo	0 / 8 / 1 0.13:1 KDA	Level10 86 (4.5) CS P/Kill 11% Tier Average Gold 2	Jun Hyos... IEDDgend EliseSmur... Double F... Vity PAI PAI 7 Celestial... Tightwhitev DoilHaveT... Kelina
Ranked Solo a day ago Defeat 15m 25s	Teemo	2 / 2 / 0 1.00:1 KDA ACE	Level10 92 (6) CS P/Kill 67% Tier Average Gold 2	The King ... Jun Hyos... Manic Gu Nate17 4Barbatos Lormagive... Sun Jun ... PopcornH Snow Da... CrazyTon...
Ranked Solo a day ago Defeat 31m 49s	Sona	3 / 9 / 15 2.00:1 KDA	Level13 5 (0.2) CS P/Kill 51% Tier Average Gold 2	XPhantomA DumbLife kilz4glory El Mitcho... rea JFla XxazirbobX 5duack Xia Tian d... Jun Hyos...
Ranked Solo a day ago Defeat 28m 48s	Blitzcrank	2 / 8 / 9 1.38:1 KDA	Level12 30 (1) CS P/Kill 44% Tier Average Gold 2	Arlozen Neechan... Kokohusky Sõny Soldat My ADC ... GÖD Emanafied Jun Hyos... lil jewboy
Ranked Solo a day ago Defeat 37m 41s	Leona	1 / 12 / 8 0.75:1 KDA	Level14 38 (1) CS P/Kill 20% Tier Average Gold 2	Capitaine FoXmaa LEOGIC Dennis th... LOVE U 3... Dörkness ChadoDesu Sheriff W... Jun Hyos... Darkaos

Automatic Data-driven Detection

- Is it possible?

Case study: League of Legends match performance summaries

- Can we catch it here?



Ranked Solo 12 minutes ago Defeat 28m 12s Jhin 7 / 9 / 12 2.11:1 KDA Level12 114 (4) CS P/Kill 59% Tier Average Gold 3	Level12 114 (4) CS P/Kill 59% Tier Average Gold 3	Keito Not Clean Jeedr Jun Hyos... AndyEaque Your Lust Slater Shonen H... PHD Mus... Altered Ti...
Ranked Solo an hour ago Defeat 29m 38s Sona 1 / 6 / 11 2.00:1 KDA Level12 12 (0.4) CS P/Kill 41% Tier Average Gold 3	Level12 12 (0.4) CS P/Kill 41% Tier Average Gold 3	Hotsfordayz MSG ME... NekoShino DaBlackT... Mr 100 LEGGING... SMITE CatKeys NotLericho Jun Hyos...
Ranked Solo an hour ago Defeat 22m 5s Lux 0 / 10 / 5 0.50:1 KDA Level9 6 (0.3) CS P/Kill 45% Tier Average Gold 3	Level9 6 (0.3) CS P/Kill 45% Tier Average Gold 3	PuLLIN... Hawkeye... im evin AD Lovoc... worlds be... niklaus222 MRkingd... Korea T.P... SDRÄ Jun Hyos...
Ranked Solo 2 hours ago Defeat 25m 36s Nautilus 0 / 10 / 7 0.70:1 KDA Level10 35 (1.4) CS P/Kill 32% Tier Average Gold 3	Level10 35 (1.4) CS P/Kill 32% Tier Average Gold 3	WE xiaolizi Justinsan... Azoth112 Stan wawa Fyuselen CuteCatJ... mir dooky... nTwFRYvo... imHereTo... Jun Hyos...
Ranked Solo a day ago Victory 30m 11s Miss Fortune 6 / 7 / 6 1.71:1 KDA Level13 139 (4.6) CS P/Kill 50% Tier Average Gold 3	Level13 139 (4.6) CS P/Kill 50% Tier Average Gold 3	YouMadC... ad222 Dokidoki JK Gamywil... KhanStor... twistedM... Limits of... Riet Povi... Jun Hyos... Ferienne
Ranked Solo a day ago Defeat 24m 38s Leona 2 / 8 / 6 1.00:1 KDA Level10 28 (1.1) CS P/Kill 57% Tier Average Gold 3	Level10 28 (1.1) CS P/Kill 57% Tier Average Gold 3	FathinGod Miss Ten... Kenshira... Smily rybojng Liu Qing... Disordersot Chen Xia... YvonneeO Jun Hyos...
Ranked Solo a day ago Defeat 24m 0s Nautilus 0 / 6 / 8 1.33:1 KDA Level10 36 (1.2) CS P/Kill 52% Tier Average Gold 3	Level10 36 (1.2) CS P/Kill 52% Tier Average Gold 3	Chippy18 NorthSR Decoy Austin Warriors... dannyypip Varkia SurfarKidill Mrs Poop... Jun Hyos...
Ranked Solo a day ago Victory 20m 29s Singed 0 / 4 / 6 1.50:1 KDA Level10 86 (4.2) CS P/Kill 29% Tier Average Gold 3	Level10 86 (4.2) CS P/Kill 29% Tier Average Gold 3	Jun Hyos... LilParoM... Melodies BEASIST Chinyo berniay Sir Salmon7 Boycad415 Mystic NL... Dife96
Ranked Solo a day ago Defeat 19m 5s Teemo 0 / 8 / 1 0.13:1 KDA Level10 86 (4.3) CS P/Kill 11% Tier Average Gold 2	Level10 86 (4.3) CS P/Kill 11% Tier Average Gold 2	Jun Hyos... ElsesSmurf Vityy Celestial... DollHaveT... IEDDgend Double F... PAI PAI 7 Tightwhitv Kaina
Ranked Solo a day ago Defeat 15m 25s Teemo 2 / 2 / 0 1.00:1 KDA Level10 82 (6) CS P/Kill 67% Tier Average Gold 2	Level10 82 (6) CS P/Kill 67% Tier Average Gold 2	The King Manic Gu Barbato Sun Jun... Snow Da... Jun Hyos... Nate17 Lornagive... PopcornH CrazyTon...
Ranked Solo a day ago Defeat 31m 48s Sona 3 / 9 / 15 2.00:1 KDA Level13 5 (0.2) CS P/Kill 51% Tier Average Gold 2	Level13 5 (0.2) CS P/Kill 51% Tier Average Gold 2	PhantomA kiz4gory Fla Kazirbotix Xia Tian d... DumbLife Ei Mitcho... Fla Sduck Jun Hyos...
Ranked Solo a day ago Defeat 28m 48s Blitzcrank 2 / 8 / 9 1.38:1 KDA Level12 30 (1) CS P/Kill 44% Tier Average Gold 2	Level12 30 (1) CS P/Kill 44% Tier Average Gold 2	Arlozen Kokohusky Soldat GÖD Jun Hyos... Neechan... Söny My ADC... Emanafied lil jebwoy
Ranked Solo a day ago Defeat 37m 41s Leona 1 / 12 / 8 0.75:1 KDA Level14 38 (1) CS P/Kill 20% Tier Average Gold 2	Level14 38 (1) CS P/Kill 20% Tier Average Gold 2	Capitaine LEOGIC LOVE U 3... ChadoDesu Jun Hyos... FoXmaa Denniss th... Dörkness Sheriff W... Darkaos

Automatic Data-driven Detection & Momentum Estimation

- As with a hired coach, identification from player history is not too difficult.
- Given full resolution, a model-based approach can likely outperform a human, who may only have time for a subset of replay segments
- ML techniques + large volume of data =
 - ✓ Objective analysis (game outcome influence)
 - ✓ Scalability (zero user setup requirements)
 - ✓ Robustness to distributional shift (including game updates)

First Approximation using Summaries Only

Features:

- Player **recent-20** match summaries
- Player **season** averages
- Character/**champion global averages** for game version (post-draft only)
- Player **on-champion proficiencies** for the season (post-draft only)

$$Y = P(\text{win} \mid \text{recent past, history, character choice, character proficiency})$$

- Specifically, # kills, deaths, assists, creep score, gold, damage dealt/taken, # wins/losses, win rates, wards placed/destroyed, past match duration, time since past match, time of day, champion class wins/losses, champion play rates, duration-normalised champion win rates...

Experimental Setup

Dataset:

- 87,743 past matches (877,430 player profiles from op.gg)
- Collected from Feb 5th – Sep 20th 2019 (season 9)
- Skill brackets sampled uniformly
- 86.4% Solo/duo queue (1 or 2), 13.6% Flex queue (1,2,3 or 5)
- 80-9-11% training-validation-test split
- 5x 5-fold stratified cross validation

Feature standardisation:

- An automatic logarithmic scaling is applied in order to normalise:

$$\alpha \circ x + \log(\beta \circ (\gamma + \max(0, x - \min(X_{\text{train}}))))$$

The parameters α , β , γ are learned via Bayesian optimisation (shared for all features in the logistic regression), or gradient descent for network (feature-specific)

Logistic regression with long-term performance deviation

- We concatenate a basic **long-term** momentum representation: the differences between recent and seasonal performance statistics
- All recent-20 features are mean averaged; **rolling statistics**/sliding window

$$\mathbf{x}^{(\text{momentum})} = \mathbf{X}_t - \mathbf{X}_{(\text{season})}$$

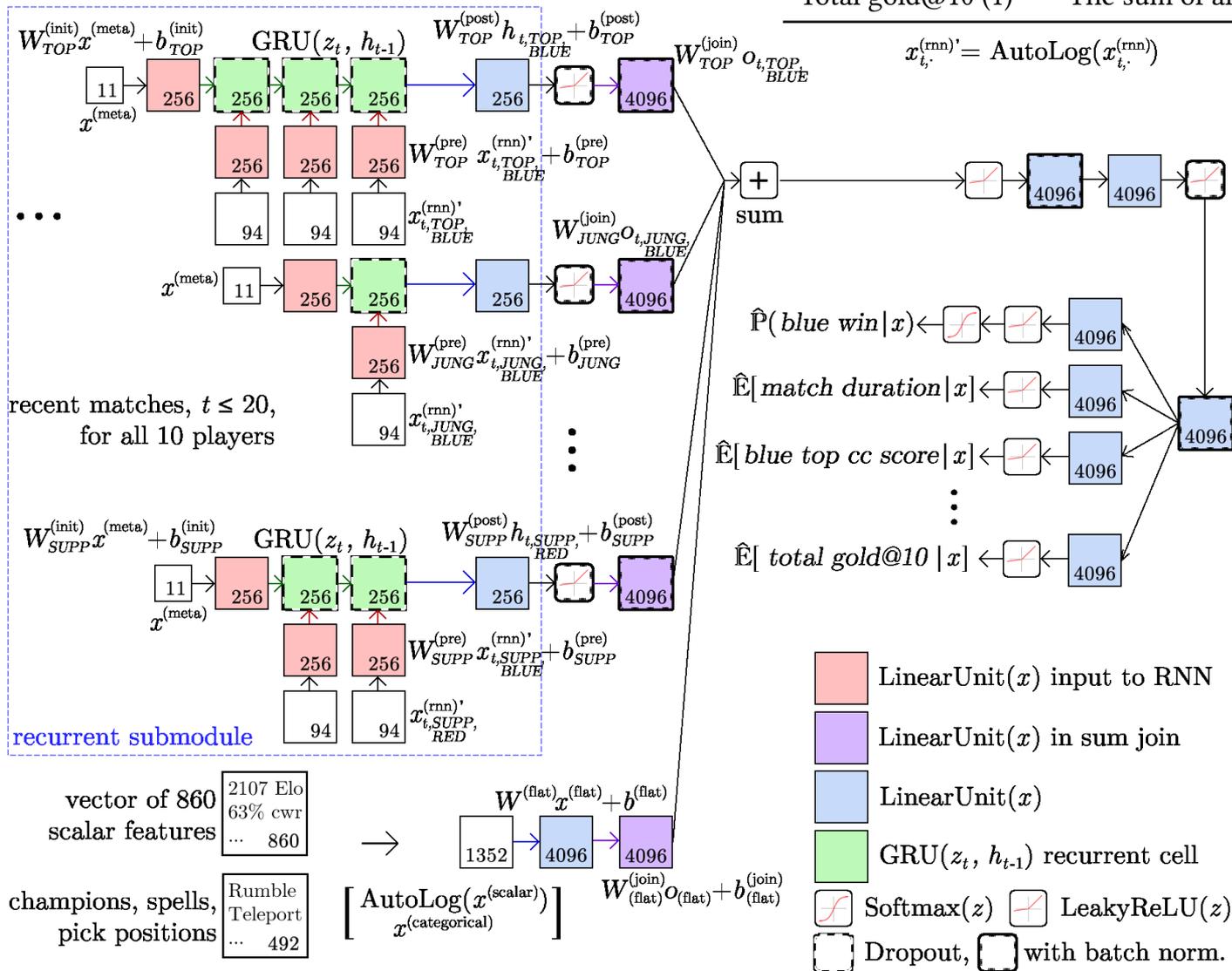
Recent-20 match
summary statistic

The same statistic,
player season average

% accuracy	Pre-draft Solo	Pre-draft Teams	Post-draft
w/ $\mathbf{x}^{(\text{momentum})}$	54.28	65.7	72.1
w/o $\mathbf{x}^{(\text{momentum})}$	54.03 (-0.25)	65.6 (-0.1)	72.0 (-0.1)
w/o any recent-20	53.59 (-0.69)	65.1 (-0.6)	71.8 (-0.3)
K-means+SVC [5]	-	-	70.4 (-1.7)

Neural Momentum Model & Multi-Task Targets

Target (# instances)	Description
Blue side win (1)	Single classification target
Match duration (1)	Length of the game
Crowd control (10)	Type-normalised cc score, per player
Vision score (10)	# wards placed or destroyed, per player
CS@10 (10)	Creep score at 10 mins, per player
Total gold@10 (1)	The sum of all players' gold at 10 mins



Neural Network Performance & Ablation Study

% accuracy	Pre-draft Solo	Pre-draft Teams	Post-draft
RNN	54.30	64.4 (-1.3)	71.1 (-1.0)
$\mathbf{x}^{(\text{momentum})}$	54.28 (-0.02)	65.7	72.1

Table 2: Post-draft network architecture importances.

Improvement	% Gain
AutoLog layer (vs. shared α, β, γ /untransformed)	0.904/2.771
Recurrent structure (RNN) (vs. Rolling/Ebbinghaus)	1.473/2.621
AMSGrad [Reddi et al. 2019] (vs. SGD/Adam)	0.643/0.587
Multi-Task Learning (MTL) (vs. Win only)	0.327
Metadata RNN initial state $Wx + b$ (vs. b alone)	0.209
Gated Recurrent Unit (GRU) cell (vs. tanh)	0.158
Role convolutions (vs. fully shared linear layers)	0.073
Dropout & Batch norm. on non-recurrent layers	0.064

Neural Network Momentum Correlation

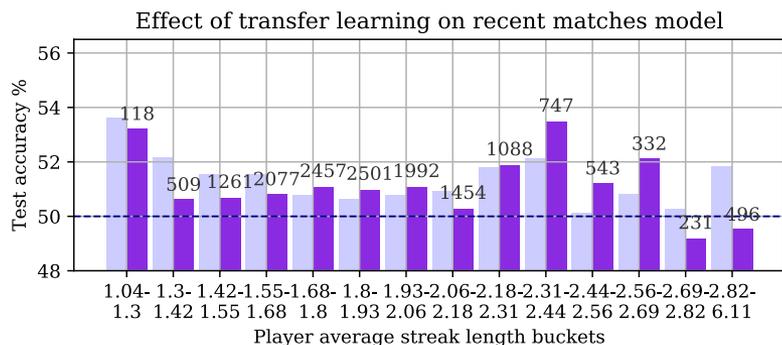


Figure 6: Accuracy for representative groups of players with similar streakiness tendency (either win or loss).

We examine players with 2 or 3 occurrences in test dataset, and $n \geq 15$ historical recent matches belonging to a complete streak, of known length, and $n \geq 15$ belonging to a complete session). Allowing outliers at the two extremes, the transfer-learned model (violet) shows a slight positive relationship. Annotations are the number of data points (players) used to compute each bar.

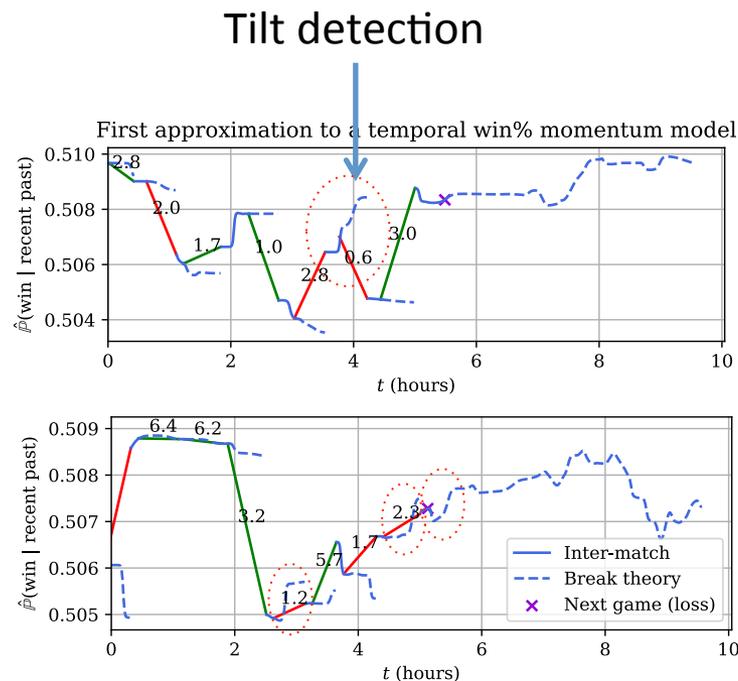


Figure 7: Two players' momentum estimates over time. Past wins are represented by green lines, losses by red, and each match is annotated with post-game KDA ratio (kills + assists ÷ deaths); a value of 2.0 is considered average. Tilt is recognised as a point where a post-match break increases win probability after around 20 minutes, though actively prompting the player to temporarily disengage, and providing an objective reason to (fig. 8), is likely to accelerate effects and aid tilt recovery [Kou et al. 2018].

Future Work: Personalised Tilt Detection and Notification – The “Flow” App. Thank You for Listening!

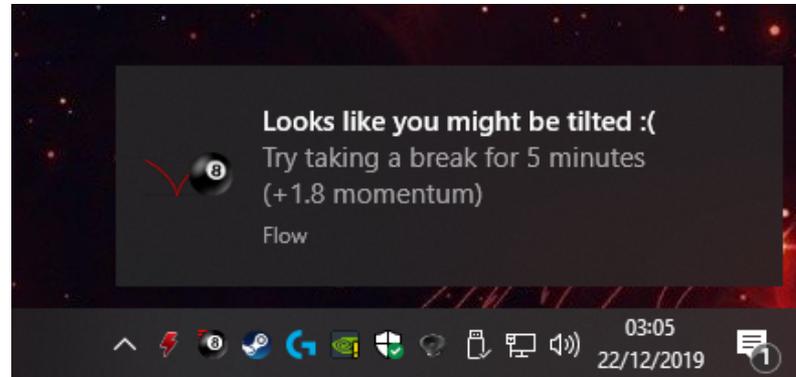


Figure 8: Example *Flow* notification.

- We propose a reinforcement learning approach in order to [learn player-specific tilt nuances](#), appropriate tilt coaching vocabulary, and how to train the player toward managing their own tilt
- Inputs: RNN momentum embeddings, tilt survey model outputs, keyboard/mouse press rates, and game client phase (lobby, in-queue etc.)
- Training can be accelerated using [Deep RL from human preferences](#) [6]