# Daily motivational underpinnings and outcomes of adolescent video gaming

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Supervisor: Aleksandra Huić, PhD, associate professor

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# DNEVNI MOTIVACIJSKI PREDIKTORI I ISHODI IGRANJA VIDEOIGARA KOD ADOLESCENATA

DOKTORSKA DISERTACIJA

Mentorica: izv.prof.dr.sc. Aleksandra Huić

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**ABOUT THE MENTOR:**

Dr. sc. Aleksandra Huić is an associate professor at the Department of Psychology, Faculty of Humanities and Social Sciences, University of Zagreb, working in the field of educational psychology. Her research interests lie in the field of self-determination theory in education, specifically teachers' (de) motivating styles in elementary, high school and higher education contexts, as well as teacher emotions and determinants of teaching quality. She has particular interests in the area of children's rights, especially the right to self-determination, and the exercise of children's rights to participation in the school context. She is also interested in the topics of gender equality and equality based on sexual orientation in the school system, and society, and in risky behaviours of adolescents, such as gambling and playing video games.

So far, she has published about fifty scientific and professional papers, and submitted about a hundred presentations at national and international conferences. She has participated in about twenty scientific projects, of which one project of the Croatian Science Foundation, a dozen domestic and international projects, and several development and technical projects, including TEMPUS, TUNING, CROQF and ESF projects. She cooperates interdisciplinary with the Faculty of Education and Rehabilitation Sciences and the Study Center for Social Work, as well as the Faculty of Food Technology and Biotechnology. She was the co-host of the XVII. and XXIV. Summer School of Psychology, and is a mentor-advisor in a number of student research projects. She is actively involved in the organization of domestic and international scientific conferences, and is also engaged in activities to popularize science as part of PsihoFest and Science Picnic.

She teaches courses in teacher competencies and educational and school psychology both for psychologists at her Department, and for numerous other teacher education programs as part of the Centre for teacher education at her alma mater.

She trained in the field of higher education teaching methods, attended the summer school of the European Association for Social Psychology, completed several workshops on advanced statistical data analyses, and a number of seminars and workshops on psychological counseling. She is the co-author of several prevention programs based in schools, and a professional educator in several programs of higher education teaching methods

She is a member of the Croatian Psychological Chamber and European Association for Research on Learning and Instruction (EARLI). She is one of the winners of the State Award for Science in the category of popularization for the 3rd PsihoFest - Festival of Psychology (2015).

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**ABSTRACT**

Many adolescents spend a significant amount of daily time playing video games. Although only a minority are problematic gamers, adolescents are still a group which could be vulnerable to the influence of video games. At the same time, gaming could be a positive force in their development. Several previous approaches were used in investigating the relationship between adolescent gaming and well-being and sleep, but they only explored a part of the picture. This study approached the issue from the perspective of the Self Determination Theory (SDT), which enabled a holistic study of both gaming motivation and the effects of gaming. It used the daily diary methodology and investigated within person relationships, which brings several advantages (e.g., reduced retrospective bias) and is unique in the field. The aim of this study was to examine the relations between basic psychological needs and gaming and between gaming and well-being and sleep. Two pilot studies were conducted first and then the main daily diary study was conducted on a sample of adolescent gamers (final N=125), who played video games every day (92% male, 4% female, 4% did not identify). The participants first filled in a baseline questionnaire and then filled in daily morning and evening questionnaires for eight consecutive days. The data were analysed by using Multilevel Structural Equation Modelling (MSEM). Results showed that the daily experienced real-life basic psychological need satisfaction and frustration was crucial in predicting the daily well-being of adolescent gamers. In-game need satisfaction contributed to their daily vitality, i.e., the feeling of energy and aliveness, and it contributed to the daily positive consequences of video games. On days when they felt real-life need frustration, the gamers actually played less video games. Once need based experiences were considered, gaming time did not contribute to neither well-being nor sleep, only gaming after midnight was weakly related to sleep quality. These results imply that real-life need-based experiences of adolescent gamers are crucial for their well-being, but they can also benefit from in-game need satisfaction. In other words, if they have positive need experiences in their life outside gaming, gaming could be an additional positive force in lives of many adolescent gamers.

Key words: video game players, adolescents, Self Determination Theory, gaming time, well-being, sleep

## PROŠIRENI SAŽETAK

### Uvod

Prema definiciji koju je dao Tavinor (2008), videoigre su proizvodi u digitalnom vizualnom mediju koji služe u prvom redu zabavi, i pružaju tu zabavu putem igre koja slijedi određena pravila i/ili putem interaktivne radnje. Neki autori dodaju da videoigre nisu samo zabavne, već da pružaju i prostor za promišljanje o „dubljim“ temama (Olivier i sur., 2016). U svakom slučaju, videoigre su široko rasprostranjene. Procjenjuje se da oko 2.7 milijardi ljudi u svijetu igra videoigre (Statista, 2023), pri čemu to čini oko 90% američkih adolescenata. Adolescenti većinom igraju na mobitelima (46%), konzolama (27%) i na PC-evima (17%). Adolescenti koji igraju na konzolama i PC-evima igraju u prosjeku oko 2 sata dnevno, dok oni koji igraju na mobitelima, igraju 1 sat dnevno (Rideout, 2015; Rideout i Robb, 2019).

Budući da su videoigre adolescentima važna aktivnost u slobodno vrijeme i da se radi o atraktivnom digitalnom mediju, pretpostavlja se da utječu na njihovu dobrobit i san. Dobrobit se može podijeliti na hedoničku, koja se odnosi na povećanje zadovoljstva i smanjenje boli i eudaimoničku, koja se odnosi na napredak i ostvarivanje potencijala (Disabato i sur., 2016). Hedonička dobrobit, odnosno njena afektivna komponenta se obično mjeri putem pozitivnog i negativnog afekta (Diener i Emmons, 1984), a eudaimoničku dobrobit autori često operacionaliziraju putem vitalnosti, koja se odnosi na osjećaj energičnosti i entuzijazma (Ryan i Frederick, 1997). Različiti čimbenici utječu na dobrobit adolescenata. U adolescenciji prijatelji postaju puno važniji i adolescenti počinju preferirati bliske interakcije i odnose (Balluerka i sur., 2016; Gross i sur., 2002). Osim prijatelja, na dobrobit adolescenata utječu i ličnost, roditelji i školsko okruženje (Steinmayr i sur., 2019), a videoigre su također jedan od čimbenika koji bi mogli imati utjecaj. Dobar san je jako važan za adolescente, pogotovo zato što su zbog svoje tendencije da s većom dobi idu sve kasnije spavati i odlaska u školu rano ujutro, mnogi u opasnosti da premalo spavaju (Gradisar i sur., 2022). Manjak sna može dovesti do umora i problema s koncentracijom, niske energije i neuspjeha u školi. Uz kofein, rani početak škole ujutro, fizičke bolesti i psihičke poremećaje, autori predlažu i da uporaba tehnologije te posebice videoigara može negativno utjecati na san adolescenata (Owens i sur., 2014; Wolfe i sur., 2014). Utjecaj videoigara na dobrobit i san adolescenata bi mogao biti izraženiji nego utjecaj na druge dobne skupine, budući da adolescenti prolaze kroz razdoblje intenzivnog fizičkog, psihosocijalnog i kognitivnog razvoja (McLauglin i sur., 2022) te su

manje savjesni i impulzivniji od odraslih i imaju niže samopoštovanje (Dienlin i Johannes, 2022).

Postoji nekoliko smjerova istraživanja i teorijskih pristupa koji povezuju igranje videoigara i dobrobit te san. Prvi pristup se odnosi na problematično igranje videoigara, koje podrazumijeva nemogućnost kontrole igranja videoigara i negativne posljedice koje ono uzrokuje u životu igrača (WHO, 2022) i zahvaća manji broj igrača. Veći postotak adolescentskih igrača provodi značajne količine vremena igrajući videoigre, a nisu problematični igrači. Drugi smjer se odnosi na uglavnom eksperimentalna istraživanja koja proučavaju utjecaj igranja videoigara na različite aspekte dobrobiti, poput uklanjanja negativnog raspoloženja (Bowman i Tamborini, 2012) ili smanjenja ruminacije kod depresivnih pacijenata (Kühn i sur., 2018). Treći smjer odnosi se na hipoteze o odnosu vremena igranja videoigara i dobrobiti i sna, pri čemu je u istraživanjima koja su koristila objektivne mjere igranja videoigara pokazano da ono nije povezano s dobrobiti. Eksperimentalna istraživanja provedena s manjim brojem sudionika i u umjetnim uvjetima su pokazala da videoigre mogu negativno utjecati na san. Ipak, ta istraživanja su gledala na odnos vremena igranja videoigara i dobrobiti i sna izolirano, bez uzimanja u obzir drugih aspekata života koji utječu na dobrobit i san. Dodatan smjer istraživanja uključuje fokusiranje na motivaciju za igranjem videoigara, gdje postoji nekoliko teorija i potencijalnih motivatora koji mogu objasniti zašto adolescenti igraju videoigre.

Ipak, samo Teorija samoodređenja (Ryan i Deci, 2017) omogućuje s jedne strane predviđanje vremena igranja videoigara, odnosno motivacijsku komponentu, i s druge strane holističko predviđanje učinaka igranja videoigara na dobrobit i san. Pri tome se uzimaju u obzir i vrijeme igranja, ali i zadovoljenje i frustracija potreba unutar videoigara i u životu izvan videoigara. Teorija samoodređenja (Ryan i Deci, 2017) je široka psihološka teorija koja se odnosi na proaktivne kapacitete osobe da selektivno interpretira i djeluje u vanjskim okruženjima, a bavi se ljudskom motivacijom, razvojem ličnosti i dobrobiti (Ryan i sur., 2022). Ova disertacija će koristiti mini Teoriju osnovnih psiholoških potreba (Ryan i Deci, 2017), koja predstavlja jednu od šest mini teorija unutar Teorije samoodređenja. Ta teorija govori o tome kako zadovoljenje osnovnih psiholoških potreba: autonomije, kompetencije i povezanosti, dovodi do psihološkog rasta i povećane dobrobiti, a frustracija, odnosno „gušenje“ potreba, dovodi do snižene dobrobiti i dugoročno do razvoja psihopatologije. Autonomija je iskustvo voljne i svjesne uključenosti u neku aktivnost koju podupiremo, kompetencija je osjećaj učinkovitosti u interakcijama s okolinom, a povezanost je potreba koju zadovoljavamo kad imamo osjećaj socijalne povezanosti, drugi brinu za nas, mi se brinemo za druge i kad imamo osjećaj

pripadanja (Ryan i Deci, 2017). Za razliku od zadovoljenja potreba, frustracija potreba je drugačiji konstrukt koji uključuje ne samo nemogućnost zadovoljenja, već i aktivno „gušenje“ potreba unutar socijalnog konteksta. Nisko zadovoljenje potreba ne mora nužno značiti i da su one frustrirane, ali frustracija potreba po definiciji uključuje nisko zadovoljenje potreba.

Zadovoljenje potreba je u dosadašnjim istraživanjima kod adolescenata bilo povezano s višim pozitivnim i nižim negativnim afektom i višim zadovoljstvom životom (Rodriguez-Meirihnos i sur., 2019), manje izraženim fizičkim simptomima i višom vitalnošću (Reinboth i sur., 2004). U dnevničkim studijama pokazana je povezanost zadovoljenja potreba s kompozitom pozitivnog i negativnog afekta (Thomaes i sur., 2017) i vitalnošću (Adie i sur., 2012). Frustracija potreba kod adolescenata je povezana s eksternaliziranim i internaliziranim problemima (Rodriguez-Meirihnos i sur., 2019), a u kontekstu dobrobiti na dnevnoj razini je dobivena povezanost s negativnim afektom (Laporte i sur., 2021). U istraživanjima sa snom kao kriterijem, pokazano je da je frustracija potreba povezana s nižom kvalitetom spavanja (Uysal i sur., 2020), a u dnevničkoj studiji na adolescentima su posrednici između frustracije potreba i kvantitete i kvalitete spavanja bili stres i umor.

Osim u životu, potrebe mogu biti zadovoljene i frustrirane i u videoigrama. Pokazano je da je zadovoljenje potreba u videoigrama povezano s višim pozitivnim i nižim negativnim afektom (Johannes i sur., 2021) te višom vitalnošću (Kosa i Uysal, 2022). Frustracija potreba u videoigrama je bila negativno povezana s vitalnošću (Kosa i Uysal, 2022). U jedinoj dnevničkoj studiji (Allen, 2020) je dobivena povezanost između zadovoljenja potreba u videoigrama i kompozita dobrobiti, ali nije dobivena povezanost s frustracijom potreba u videoigrama.

Osim dobrobiti i sna, potrebe mogu predviđati i vrijeme igranja, što se odnosi na motivaciju za igranjem videoigara. U dosadašnjim istraživanjima je pokazano da je zadovoljenje potreba u igrama pozitivno predviđalo vrijeme igranja (npr. Allen i Anderson, 2018), ali ta povezanost nije dobivena za frustraciju potreba u videoigrama. Neki autori pretpostavljaju kako je frustracija potreba u životu izvan videoigara povezana s većim vremenom igranja (Ryan i Rigby, 2011), odnosno kako igrači videoigara na taj način kompenziraju nemogućnost zadovoljenja potreba u stvarnom životu. Ta povezanost je pokazana u kros-sekcijskim istraživanjima (npr. Mills i sur., 2018a), ali u jedinoj dnevničkoj studiji (Allen, 2020) je dobivena negativna povezanost između frustracije potreba u životu izvan videoigara i vremena igranja, što znači da igrači zapravo igraju manje na dane kad su im frustrirane potrebe.

Osim manjka istraživanja koja bi objedinila sve bitne teorijske elemente, područje istraživanja motivacije i učinaka videoigara unutar okvira Teorije samoodređenja ima i metodoloških poteškoća koje onemogućuju donošenje kvalitetnih zaključaka. Dosad su uglavnom korišteni kros-sekcijski nacrti, koji imaju niz mana poput nemogućnosti kauzalnog zaključivanja i razdvajanja varijance između osoba i varijance unutar osobe. Klasični longitudinalni nacrti također imaju velike i često arbitrarno određene razmake između mjerenja, a eksperimentalni nacrti, iako kauzalno superiorni, se provode u umjetnim uvjetima. Nacrt dnevničke studije, odnosno intenzivno longitudinalni nacrt (Bolger i Laurenceau, 2013), omogućuje analiziranje efekata unutar osobe, odnosno primjerice proučavanje da li zadovoljenje potreba na dnevnoj razini koje je iznad dnevnog prosjeka osobe prati razina vitalnosti koja je iznad dnevnog prosjeka osobe. Odnosi unutar osobe omogućuju i korištenje osobe kao kontrole samoj sebi, što omogućuje eliminiranje utjecaja stabilnih trećih varijabli poput demografije i ličnosti. Dodatna prednost je i umanjenje retrospektivne pristranosti, što je posebno korisno za mjerenje objektivnih ponašanja poput vremena igranja i spavanja.

Sve u svemu, ovo istraživanje je, na teorijskoj razini ponudilo predviđanje vremena igranja, dobrobiti i spavanja adolescentskih igrača videoigara, uz korištenje svih teorijski relevantnih varijabli u jednom modelu proizašlom iz Teorije samoodređenja (Ryan i Deci, 2017). Prethodna istraživanja bi primjerice koristila samo zadovoljenje potreba u videoigrama, ali ne i zadovoljenje potreba u životu izvan videoigara, ili bi samo putem vremena igranja predviđala dobrobit, bez istovremenog korištenja konstrukata potreba. Na metodološkoj razini je ovo istraživanje koristilo intenzivno longitudinalni nacrt dnevničke studije, što je omogućilo proučavanje efekata unutar osobe i smanjenje retrospektivne pristranosti. Ovo istraživanje je također uključilo i različite operacionalizacije dobrobiti kao kriterija te je uključilo mjerenje spavanja, što je jedinstveno za dnevničku studiju provedenu na igračima videoigara. Također, ono je provedeno na jedinstvenoj populaciji adolescentskih igrača koji svakodnevno igraju videoigre.

**Ciljevi i problemi istraživanja**

Cilj istraživanja je bio proučiti odnose između osnovnih psiholoških potreba i igranja videoigara te između igranja videoigara i dobrobiti i spavanja. Istraživanje je pokušalo dati odgovor na tri problema: 1.) Da li zadovoljenje i frustracija osnovnih psiholoških potreba u videoigrama i u životu izvan videoigara predviđaju vrijeme igranja videoigara i dobrobit, direktno i indirektno kroz vrijeme igranja videoigara? 2.) Da li zadovoljenje i frustracija

potreba u videoigrama i u životu izvan videoigara predviđaju spavanje, direktno i indirektno preko vremena igranja? i 3.) Da li vrijeme igranja predviđa dobrobit i spavanje?

## Metodologija istraživanja

### Postupak

Istraživanje je uključivalo dva pilot istraživanja: prvo u kojem se u fokusnim grupama (N=4) provjeravalo razumiju li sudionici prijevode instrumenata i imaju li sugestija za njihovo poboljšanje i drugo u kojem je glavno istraživanje probno provedeno na manjem broju sudionika (N=10).

Nakon dovršetka pilot istraživanja i nakon što su uvažene sugestije sudionika proizašle iz njih, provedeno je glavno istraživanje. Sudionici su za njega kontaktirani putem članka kojeg je objavio portal specijaliziran za videoigre (FFA.hr Gaming Portal) te su kontaktirani sudionici koji su sudjelovali u prethodnom kvalitativnom istraživanju (a stavite referencu sad objavljenog rada :D) i korišten je princip „snježne grude“. Na kraju istraživanja, sudionici su dobili bon za platformu Steam u vrijednosti od 10 eura. Kako bi sudjelovali u istraživanju, sudionici su trebali pohađati srednju školu i igrati videoigre svakodnevno. Sudionici su prvo preuzeli aplikaciju „Expi Well“, pristali na sudjelovanje u istraživanju, napisali kratki akcijski plan u kojem su trebali svojim riječima napisati da će svakodnevno popunjavati upitnike ujutro i navečer, i ispunili početni upitnik. Potom su osam dana za redom ujutro kad bi se probudili popunjavali jutarnji upitnik, a navečer prije spavanja popunjavali večernji upitnik. U sklopu jutarnjeg upitnika, sudionici su odgovarali na pitanja o spavanju prethodne večeri, a u večernjem upitniku su odgovarali na ostala pitanja.

### Sudionici

Ukupno je 169 sudionika započelo sudjelovanje u istraživanju. Nakon isključivanja sudionika koji su popunili samo početni upitnik (n=9) ili nisu popunili više od 50% večernjih upitnika (n=29) te isključivanja sudionika koji su bili bolesni za vrijeme istraživanja (n=1), roditelji im nisu dozvoljavali da igraju videoigre (n=2) i onih koji nisu igrali videoigre tijekom polovice ili više dana za vrijeme istraživanja (n=4), na kraju je n=125 sudionika uključeno u konačni uzorak. Ti sudionici su uglavnom bili mladići (92%, uz 4% djevojaka i 4% sudionika koji nisu htjeli navesti svoj rod), a njihova prosječna dob je bila 17.28 godina (*SD*=1.18 godina).

### Mjerni instrumenti

Početni upitnik je sadržavao pitanja o demografskim karakteristikama sudionika te je sadržavao upitnike koji su mjerili stabilne konstrukte: Poremećaj igranja videoigara, harmoničnu i opsesivnu strast za igranjem videoigara i samokontrolu. Na dnevnoj razini je svakodnevno, tijekom osam dana istraživanja, jutarnjim upitnicima mjerena kvaliteta i količina sna sudionika. Večernjim upitnicima su svakog dana mjereni: zadovoljenje i frustracija potreba u videoigrama i u životu izvan videoigara, vrijeme igranja videoigara, žanrovi videoigara igranih na taj dan, pozitivni i negativni afekt, vitalnost, fizički simptomi, pozitivni i negativni učinci videoigara te da li je pojedini dan na neki način bio neobičan.

Analiza podataka

Podaci su analizirani putem višerazinskog strukturalnog modeliranja (MSEM; Hallquist, 2017; Sadikaj i sur., 2021). Proučavani su odnosi unutar osobe, a kao kontrolne varijable u svim modelima korišteni su i broj ispunjenih upitnika od početka istraživanja, kako bi se kontrolirala činjenica da samim ispunjavanjem upitnika može doći do promjene rezultata, i da li je određeni dan bio vikend, kako bi se kontrolirala činjenica da tijekom vikenda dolazi do povećanja dobrobiti.

**Rezultati i rasprava**

Prvi istraživački problem mogao bi se podijeliti na dva dijela: kako konstrukti potreba predviđaju vrijeme igranja i kako potrebe i vrijeme igranja predviđaju dobrobit.

U prvom dijelu je dobiveno da zadovoljenje potreba u videoigrama predviđa vrijeme igranja, odnosno da ako osoba zadovolji svoje potrebe u videoigrama iznad dnevnog prosjeka taj dan će i više igrati videoigre. Taj nalaz je očekivan s obzirom na teoriju i prethodna istraživanja (Ryan i sur., 2006; Quist, 2016). Konkretno, za jednu jedinicu povećanja zadovoljenja potreba u videoigrama (na skali od 1 do 5) iznad dnevnog prosjeka osobe, dnevno vrijeme igranja bi se povećalo za jedan sat i 44 minute. Ipak, taj nalaz nije bio konzistentan kroz modele, što se može pripisati i nedovoljnoj statističkoj snazi. Dnevna frustracija potreba u videoigrama nije bila povezana s dnevnim vremenom igranja, što je bio pomalo neočekivan nalaz. Budući da je većina adolescentskih igrača igrala *multiplayer* videoigre, moguće je da su zbog socijalnog pritiska nastavljali igrati unatoč frustraciji doživljenoj taj dan (Krassen & Aupers, 2022). Budući da su konstrukti zadovoljenja i frustracije potreba u videoigrama zapravo samo prilagođeni iz instrumenata koji mjere zadovoljenje i frustraciju potreba u životu, vjerojatno bi bilo najbolje konstruirati nove mjere koje bi adekvatnije zahvatile te konstrukte. Frustracija potreba u životu izvan videoigara je bila negativno povezana s vremenom igranja, odnosno na

dane kad bi igrači doživjeli frustraciju potreba iznad svog dnevnog prosjeka, igrali bi videoigre manje od svog dnevnog prosjeka. Konkretno, kad bi se dnevna frustracija potreba povećala za jednu jedinicu (na skali od 1 do 5) iznad dnevnog prosjeka sudionika, dnevno vrijeme igranja bi se smanjilo za jedan sat i 13 minuta ispod dnevnog prosjeka. Taj nalaz je suprotan hipotezi prema kojoj igranje videoigara može biti kompenzacija za frustrirane potrebe u životu. Ipak, ovaj nalaz je u skladu s prethodnom dnevničkom studijom na igračima videoigara (Allen, 2020) i kvalitativnim istraživanjem na adolescentskim igračima videoigara (Razum i Huić, 2023). Čini se kako adolescenti na dane kada su im potrebe frustrirane manje igraju kompetitivne videoigre koje inače igraju te igraju opuštajuće videoigre koje su i manje vremenski zahtjevne. To ipak ne isključuje mogućnost da oni adolescenti kojima su potrebe u životu kronično frustrirane, dugoročno tu frustraciju ipak kompenziraju kroz videoigre.

Drugi dio prvog problema se odnosio na to kako dnevno ispunjenje i frustracija potreba predviđaju dnevnu dobrobit adolescentskih igrača videoigara. Dobiveno je da su dnevno zadovoljenje i frustracija potreba u životu izvan videoigara snažni prediktori dnevne dobrobiti. Preciznije, kad bi dnevno zadovoljenje potreba adolescenata poraslo jednu standardnu devijaciju iznad njihovog dnevnog prosjeka, pozitivni afekt bi se povećao za 0.46 standardnih devijacija, negativni afekt smanjio za 0.26 standardnih devijacija, a vitalnost povećala za 0.32 standardne devijacije iznad dnevnog prosjeka. Kad bi dnevna frustracija potreba adolescenata porasla za jednu standardnu devijaciju iznad dnevnog prosjeka, pozitivni afekt adolescenata bi se smanjio za 0.41 standardnu devijaciju, vitalnost smanjila za 0.29 standardnih devijacija, a intenzitet doživljenih glavobolja povećao za 0.24 standardne devijacije iznad dnevnog prosjeka. Zanimljivo je da dnevna frustracija potreba u životu izvan videoigara nije predviđala dnevni negativni afekt adolescenata, iako bi to bilo očekivano jer je frustracija potreba i kreirana kao konstrukt kako bi bolje od zadovoljenja potreba predviđala negativne ishode poput eksternaliziranih i internaliziranih poteškoća (Ryan i Deci, 2017). Moguće je da bi dnevna frustracija potreba bila povezana s negativnijim ishodima poput depresivnosti i anksioznosti, kao što je bila i jedinstveno povezana s dnevnim intenzitetom doživljenih glavobolja u ovom istraživanju, a moguće je i da se zadovoljenje i frustracija potreba kod adolescenata ne razlikuju dovoljno kao konstrukti. U svakom slučaju, dnevno zadovoljenje i frustracija potreba u životu izvan videoigara kod adolescenata su bili dominantni prediktori dnevne dobrobiti operacionalizirane putem pozitivnog i negativnog afekta, vitalnosti i fizičkih simptoma (glavobolja).

Od konstrukata dnevnog zadovoljenja i frustracije potreba u videoigrama, jedino je dnevno zadovoljenje potreba u videoigrama predviđalo dnevnu vitalnost povrh zadovoljenja potreba u životu izvan videoigara. Preciznije, za povećanje od jedne standardne devijacije iznad dnevnog prosjeka u zadovoljenju potreba u videoigrama, dnevna vitalnost se povećala za 0.19 standardnih devijacija iznad dnevnog prosjeka. Ovaj nalaz govori o doprinosu videoigara dnevnoj dobrobiti, pri čemu se radi o povećanju dnevne vitalnosti, odnosno svakodnevnog osjećaja energiziranosti i živosti. Vitalnost je konstrukt eudaimoničke dobrobiti, što je tip dobrobiti koji se odnosi na „cvjetanje“ i dosezanje vlastitog potencijala (Disabato i sur., 2016). S iznimkom vitalnosti, zadovoljenje i frustracija potreba u životu izvan videoigara su bili ključni u predviđanju dobrobiti. Ipak, konstrukti potreba u videoigrama su pridonijeli dobrobiti specifičnoj za videoigre. Za povećanje od jedne standardne devijacije iznad dnevnog prosjeka u zadovoljenju potreba unutar videoigara, dnevne pozitivne posljedice igranja videoigara povećale bi se za 0.2 standardnih devijacija. Dnevno zadovoljenje potreba u videoigrama nije doprinijelo samo vitalnosti adolescenata, već i tome koliko su osjećali da su im videoigre taj dan donijele dobre stvari, poput učenja nečeg novog ili druženja s drugima. Doprinos dnevnog zadovoljenja potreba u videoigrama dnevnoj vitalnosti i pozitivnim posljedicama igranja videoigara ukazuje na to da su videoigre više od jednostavne zabave i da možda mogu doprinijeti pozitivnom razvoju adolescenata (Adachi i Willoughby, 2013). Ovaj nalaz ukazuje i na to da se pozitivni učinci videoigara mogu objasniti zadovoljenjem potreba kao posredujućim mehanizmom. Dnevna frustracija potreba u videoigrama je, s druge strane, bila povezana s dnevnim negativnim posljedicama igranja videoigara. Povećanje od jedne standardne devijacije iznad dnevnog prosjeka u frustraciji potreba u videoigrama bilo je povezano s povećanjem negativnih posljedica igranja videoigara (nedostatak vremena za drugu važnu aktivnost zbog igranja) od 0.41 standardne devijacije iznad dnevnog prosjeka. Ovaj nalaz je neobičan jer u isto vrijeme frustracija potreba u životu izvan videoigara nije imala doprinos u objašnjenju negativnih posljedica igranja videoigara. Valja ipak napomenuti da su konstrukti frustracije potreba u videoigrama i frustracije potreba u životu izvan videoigara vrlo visoko korelirali. Također, moguć je obrnut smjer odnosa u kojem u danu u kojem doživi negativne posljedice igranja videoigara adolescent zbog toga dok igra osjeća višu razinu frustracije potreba u videoigrama.

Drugi istraživački problem se odnosio na odnos potreba, vremena igranja i kvalitete i duljine spavanja. Za razliku od prethodnog problema, svi odnosi su bili neznačajni te zadovoljenje i frustracija potreba u videoigrama i u životu izvan videoigara i vrijeme igranja nisu bili povezani

s dnevnom kvalitetom i duljinom spavanja. Zadovoljenje i frustracija potreba mogli bi ipak biti povezani sa spavanjem indirektno putem medijatora koji nisu ispitani u ovom istraživanju. Primjerice, u dnevničkoj studiji Campbellove i suradnika (2021) provedenoj na adolescentima, dnevni umor i stres su bili posrednici u odnosu između dnevne frustracije potreba i kvalitete spavanja.

Treći istraživački problem se odnosio na vezu između vremena igranja videoigara i dobrobiti i spavanja. U testiranim modelima vrijeme igranja nije bilo značajno povezano niti s jednim od ovih kriterija, osim s pozitivnim posljedicama igranja videoigara kao operacionalizacijom dobrobiti. Pri tome se radilo o relativno malom učinku, odnosno uslijed povećanja vremena igranja od jednog sata iznad dnevnog prosjeka adolescenata, pozitivne posljedice igranja videoigara bi se povećale za 0.08 jedinica iznad dnevnog prosjeka. Ovaj odnos se može interpretirati i tako da su sudionici onda kada su osjećali više pozitivnih učinaka igranja videoigara, također i više igrali. U tom odnosu je testiran i *random slope* model, kako bi se ispitala heterogenost učinaka, te je utvrđeno kako većina sudionika ima pozitivan odnos vremena igranja i pozitivnih posljedica videoigara, ali neki imaju i blago negativan odnos. Odnos između vremena igranja i kvalitete i duljine spavanja nije bio značajan, osim kad se izoliralo vrijeme igranja poslije ponoći. U tom slučaju je odnos bio blago negativan, odnosno za svaki sat igranja poslije ponoći iznad dnevnog prosjeka osobe, kvaliteta sna bi se smanjila za 0.12 jedinica. U odnosima između vremena igranja i pozitivnih i negativnih posljedica videoigara te između vremena igranja i kvalitete i duljine spavanja testirani su i različiti moderatori: harmonična i opsesivna strast, žanr najviše igranih videoigara na određeni dan i samokontrola. Pokazalo se kako niti jedan od moderatora nije moderirao ove odnose, vjerojatno i zato što nije bilo dovoljno varijance u učincima među pojedincima, a koju bi onda moderatori objasnili. Ovi nalazi pokazuju kako su zadovoljenje i frustracija potreba u životu izvan videoigara i donekle u videoigrama ključni za objašnjavanje dnevne dobrobiti, te da vrijeme igranja za većinu kriterija nema nikakav dodatni doprinos. Vjerojatno se radi o tome da adolescenti koji zadovoljavaju i ne frustriraju svoje potrebe u životu izvan videoigra, znaju odgovarajuće rasporediti i vrijeme igranja. To vrijedi i za vrijeme igranja poslije ponoći, koje zapravo ima vrlo slabu negativnu povezanost s kvalitetom spavanja. Glavni krivci za loš san adolescenata su vjerojatno drugi faktori poput ranojutarnjeg početka škole, fizičkih i psihičkih bolesti i kofeina (Owens i sur., 2014).

Ovo istraživanje ima i određena ograničenja, poput činjenice da proučavani odnosi nisu kauzalni i da im mi zapravo ne znamo smjer, iako se radi o odnosima unutar osobe. Također,

ne možemo znati kakvi su dugoročni efekti i rezultati se ne mogu generalizirati na sve adolescentske igrače videoigara. Ipak, ovo istraživanje je bilo fokusirano na specifičan uzorak adolescenata koji igraju videoigre svakodnevno i proučavalo je odnose unutar osobe na dnevnoj razini u prirodnom okruženju igrača videoigara. Također, kontrolirane su relevantne varijable, varijable su mjerene uz malo retrospektivne pristranosti, a nacrt unutar osobe sam po sebi kontrolira utjecaj stabilnih osobina (npr. demografske karakteristike, ličnost) na proučavane odnose. Samim time je ovo istraživanje jedinstveno i pruža mogućnosti za donošenje zaključaka kakvi nisu bili mogući u dosadašnjim istraživanjima.

## Zaključak

U ovom istraživanju dobiveno je kako su zadovoljavanje potreba i u isto vrijeme što niža frustracija potreba u životu izvan videoigara ključni u objašnjavanju dnevne dobrobiti adolescentskih igrača videoigara. Zadovoljavanje potreba u videoigrama dodatno doprinosi dnevnom osjećaju vitalnosti, tj. energičnosti i živosti te doprinosi doživljenim pozitivnim posljedicama igranja videoigara. Ovi nalazi govore o doprinosu videoigara pozitivnom razvoju adolescenata. Za razliku od prijašnjih kros-sekcijskih nalaza, dobiveno je kako na dane kad su adolescentima frustrirane potrebe u životu izvan videoigara, oni zapravo igraju manje. Ovaj nalaz pruža uvid u mehanizme korištenja videoigara za suočavanje sa životnim problemima te su potrebna daljnja metodološki kvalitetna istraživanja koja bi otkrila u kojim slučajevima je to suočavanje maladaptivno. Vrijeme igranja nije imalo nikakav doprinos dnevnoj dobrobiti povrh zadovoljavanja i frustracije potreba te je imalo vrlo slabu vezu sa spavanjem. Ovaj nalaz potvrđuje kako treba maknuti fokus s vremena igranja i pomaknuti ga prema zadovoljavanju i frustraciji potreba kako bi smo shvatili što pridonosi dnevnoj dobrobiti adolescentskih igrača videoigara.

Ključne riječi: igrači videoigara, adolescenti, teorija samoodređenja, vrijeme igranja, dobrobit, san

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*"The old adage goes "Debates in academia are so vicious because the stakes are so small." Presumably, this half-joke is meant to poke fun at the insularity of so many academic deliberations that may focus on minor points of pedagogy about which most regular people do not care. However […] People outside of academia really do care one way or another about video games. Sure, video games are not akin to a cure for cancer, grinding world poverty, or looming threats of war or global warming. Nevertheless, technology clearly does fascinate people, sometimes frightening them, at other times offering the promise of something wondrous."*

Christopher J. Ferguson, in Video Game Influences On Aggression, Cognition and Attention (2018, pp. 3).

## 1. INTRODUCTION

Consider the example of Jeff (15). He likes to play video games in his free time. He plays almost four hours every day, mainly multiplayer games such as *League of legends* and *Rocket League*, but sometimes also single player strategic and other games. Besides playing, he talks to his gaming buddies via Discord and meets other people. In the rest of his free time, he likes to play sports and go out with friends. His parents think that he plays too much and that he should perhaps be doing other, more useful, or healthy things. They have heard it in the media that adolescents should spend less time using screens and spend more time in nature, that they should replace "screen time" with "green time". Every day, Jeff sits in interesting or less interesting classes in school, he succeeds or fails in exams, and he feels more or less connected to his friends when they sit in a caffe and drink coffee. In a darker scenario, on a given day he could fail an important exam, he could feel that the entire day is just a string of boring and strenuous tasks, or he could be bullied. All these things contribute to his daily sense of well-being.

The Self Determination Theory (Ryan & Deci, 2017) states that the basic psychological needs: autonomy, competence and relatedness are the key ingredients of our well-being. When Jeff is freely choosing what to do, succeeds in an exam, and feels connected with friends, his needs for autonomy, competence and relatedness are satisfied. When he is forced to sit in classes that he sees as useless and boring, when he fails an important exam or is being bullied, his needs for autonomy, competence and relatedness are frustrated. Based on research within SDT and more specifically Basic Psychological Need Theory (BPNT), we can assert that Jeff's well-being rises when his needs are satisfied, and he experiences ill-being when his needs are frustrated. These same needs can be satisfied and frustrated within video games as well, which can provide a contribution to well-being. However, it is not certain to which extent do the satisfaction and frustration of needs within video games contribute to well-being of adolescents, when taking into account the real-life need experiences and their contribution. The research field would also benefit from research asking whether frustration of real-life needs would lead to more playing time to compensate for it, and from research asking about the effects of time spent playing video games on different aspects of well-being and sleep. This dissertation will use a daily diary design and follow a sample of adolescent gamers for multiple

consecutive days. It will seek to answer these and other questions, with the aim of exploring the relations between basic psychological needs, gaming, and well-being and sleep.

### 1.1 Defining video games

It is surprisingly hard to define video games in a way which would capture all shapes and forms that they appear in (Tavinor, 2008). Tavinor (2008, pp.12) attempted to give an universal definition: "X is a videogame if it is an artefact in a digital visual medium, is intended primarily as an object of entertainment, and is intended to provide such entertainment through the employment of one or both of the following modes of engagement: rulebound gameplay or interactive fiction." Granic et al. (2014) note that video games differ from other forms of media (e.g., books, tv, movies) because a player can actively engage with the game world and the game can in turn react to the player's behaviour. They propose that all games can be placed in a coordinate system defined by two dimensions of complexity and cooperation, but they also admit this is an oversimplification. Although it is not easy to provide an all-encompassing definition of video games, there are usually not many disagreements about whether something is a video game or not.

Video games are a widely present form of entertainment. The gaming industry is currently worth 248 billion dollars and is growing at an annual rate of 9% (Techjury, 2023). It is estimated that around 2.7 billion people in the world play video games (Statista, 2023), some of them casually, while for others playing video games may be a very serious hobby (Newzoo, 2020). US studies estimate that around 90% of adolescents aged 13 to 17 play video games (Pew Research Centre, 2018). Around 46% of 13- to 18-year-olds play mobile games, 27% play on consoles and 17% play on PCs (Rideout & Robb, 2019). Adolescents who play on PCs spend on average 2 hours and 14 minutes per day playing, those who play on consoles spend 2 hours and 9 minutes, while mobile players average 1 hour and 12 minutes of daily play (Rideout, 2015; Rideout & Robb, 2019). As a significant free time activity that takes place in the virtual world, it is assumed that video games bear an influence on the well-being and sleep of adolescents.

### 1.2 Well-being and sleep in adolescence

Mental health can be divided into positive and negative mental health, with negative mental health referring to psychopathology, and positive mental health referring to well-being (Greenspoon & Saklofske, 2001). Although the two concepts are substantially empirically related (Bartels et al., 2013), having no psychopathological issues does not equate to having

high well-being (Greenspoon & Saklofske, 2001). Defining and subsequently assessing well-being is a complex issue (Dodge et al., 2012). Historically, there are two broad traditions in studying well-being stemming all the way from the Greek philosophers Aristippus and Aristotle, namely the hedonic tradition, which represents the maximization of pleasure and minimization of pain and the eudaimonic tradition, which represents human flourishing and living up to one's potential (Disabato et al., 2016). A cross-cultural study by Disabato et al. (2016) has shown that these two traditions empirically converge toward the same superordinate construct. In the most known and accepted hedonic model, Diener and Emmons (1984) proposed that the subjective well-being consists of life satisfaction, which represents the cognitive domain of well-being, and the positive and negative affect, which represent the affective components of well-being. Life satisfaction is thought of as a cognitive component because it reflects attitudes about one's life and positive and negative affect relate to the amount of positive and negative feelings people experience in their lives (Schimmack, 2008). Unlike hedonic well-being, there is far less agreement about what constitutes eudaimonic well-being, apart from the fact that eudaimonia should include a component of personal meaning and growth, and exclude the affect component (Disabato et al., 2016). In their model of eudaimonic well-being, Ryff (1989; Ryff & Singer, 2008) proposed that it consists of six dimensions that they derived from previous philosophical and psychological theories: self-acceptance, purpose in life, environmental mastery, positive relationships, personal growth, and autonomy. Ryan and Frederick (1997) proposed a dimension of vitality, which corresponds to feeling energetic and enthusiastic.

Different factors influence the well-being of adolescents. Social relations are particularly important (Balluerka et al., 2016). Adolescents start to transfer attachment figures from their parents to close friends, and their peers start to fulfil attachment functions of proximity and safe haven (Balluerka et al., 2016). Adolescents start to prefer intimacy and close and meaningful interactions (Gross et al., 2002). They turn to peers in times of distress, but their parents are still important, and can have a positive impact on their children's well-being if they have high parental warmth and low strictness (Steinmayr et al., 2019). Apart from friends and parents, schools are also valuable contributors (Steinmayr et al., 2019). Adolescents' well-being is influenced by their school achievement (Steinmayr et al., 2019), and bullying creates a strong negative influence on the well-being of adolescents (Orben & Przybylski, 2019). Personality is also relevant, as extroverted adolescents tend to have higher well-being

(Steinmayr et al., 2019). Video games reside among all these and other factors as a possible influence on an adolescent's life and well-being. Besides well-being, another crucial aspect of an adolescent's life that was suggested to be influenced by video games is sleep.

Getting a good night's sleep is incredibly important. It helps humans to maintain high levels of cognitive functioning: to think clearly, to be vigilant, alert and to sustain attention (Worley, 2018). During sleep we consolidate memories, and it plays an important role in emotional regulation (Worley, 2018).

Adolescence is a unique period in life regarding sleep, since sleep onset for adolescents becomes later as they age (Gradisar et al., 2022), which does not happen during any other period in life. Due to their natural tendency to delay their sleep and because schools in many countries start too early for them (Gradisar et al., 2022; Alfonsi et al., 2020), adolescents are at risk of not sleeping enough. Adolescents who sleep too little are tired, have problems concentrating, have low energy, experience problems socializing and have poor school performance. They can experience a decline in mood, depression and can even engage in suicidal ideation and attempt suicides (Owens et al., 2014; Gradisar et al., 2022). The link between the lack of sleep and depression may be more pronounced during adolescence than during other periods of life (Gradisar et al. 2022). Lack of sleep in adolescents can also contribute to obesity and cause driving accidents (Owens et al., 2014).

Several factors were proposed as contributors to a lack of adolescent sleep. Caffeine and energy drinks intake was related to poorer sleep and caused a decrease in slow wave sleep (Owens et al., 2014). Chronic medical illnesses, in particular chronic respiratory illnesses, and mental health issues such as anxiety and stress were related to sleep difficulties (Owens et al., 2014). As mentioned before, early school start times were marked as an important culprit (Alfonsi et al., 2020). Alongside these factors, several authors proposed that the use of digital technology and video games in particular can also contribute to poorer sleep in adolescents (Owens et al., 2014; Wolfe et al., 2014).

### 1.3 How are video games related to adolescents' well-being and sleep?

From the previously outlined data, it is clear that many adolescents spend substantial amounts of daily time playing video games. However, many adults also play for large amounts of hours. The influence of video games on adolescent well-being and sleep may be more important

and/or amplified because of the specific characteristics that this population has. Adolescents are undergoing a period of intense physical, psychosocial and cognitive development (McLaughlin et al., 2022; Steinberg, 2005) and well-being and sleep are important for this development (e.g., Owens et al., 2014). Adolescents are also different than adults in terms of personality and other characteristics. They are more socially oriented than adults, more open minded, less conscientious, and more impulsive (Dienlin & Johannes, 2022). Their life satisfaction and self-esteem are usually lower than they will be during the rest of their lives (Dienlin & Johannes, 2022). Different forms of digital technology and video games in particular, could therefore exert a stronger influence on the well-being and sleep of adolescents than on adults. Several authors (Dienlin & Johannes, 2022; Orben & Przybylski, 2019) stated that these concerns may be overblown, because adolescents may already possess media knowledge, there are in fact not that many differences between adolescents and adults, and we tend to patronize adolescents with regards to technology use. However, due to their ongoing development, described personality traits such as lower conscientiousness and higher impulsivity, and lower self-esteem, adolescents are probably more vulnerable to the influence of technology and video games. One author described adolescents in this context as "canaries in a coalmine" (Livingstone, 2018), hinting that if anyone, they will be the first ones to be affected by technology.

Policy makers have shared these concerns and questions about technology use and video gaming in particular have been added to the household panel surveys and other representative surveys (Orben & Przybylski, 2019). For example, the European School Survey Project on Alcohol and Other Drugs (ESPAD, The ESPAD Group, 2019), which is conducted on 16-year-olds, now includes questions about social media and video game use. Many parents also voice concerns about their children's gaming behaviour. In a recent US national poll (Mott poll report, 2020), 86% of parents agreed or strongly agreed that their adolescents spend too much time playing video games and many of them tried different strategies to limit their gaming time, often by encouraging them to engage in other activities. In 2021, China introduced measures that were hailed as "draconian" by prominent researchers in the field (Colder Carras et al., 2021) and that limited the gaming time of minors to just three hours per week. In 2011, South Korea introduced the so-called "Shutdown law", which banned gaming for minors from midnight to 6am, in an attempt to improve their sleep (Lee et al., 2017). As Johannes et al. (2021) have noticed, the attention of policy makers and the public has shifted away from

concerns about gaming causing aggression, which has received weak scientific support (Drummond & Sauer, 2018) to the relationship of gaming and well-being and sleep.

Besides the basic theoretical ideas pointing at the sensitivity of adolescents to the influence of video games and the attention the topic has received from policy makers and parents, multiple theoretical approaches and a lot of research conducted until now directly or indirectly connected video games with well-being and sleep of adolescents. This could be divided into several research streams. First, there is research about problematic gaming, which represents a psychopathological entity that very negatively affects a minority of gamers. Second, there is research about the effects of gaming on different criteria directly or indirectly related to well-being, such as creativity and mood. This line of research also includes a basic question of how gaming time is related to well-being and sleep. Finally, there is research that rather than asking just about the effects, asks about the motivational antecedents of playing video games, trying to answer the question of why adolescents play video games. One of the theories applied within this stream, the Self Determination Theory (SDT, Ryan & Deci, 2017) also allows the connection between the motivational antecedents of gaming and well-being and sleep, thus enabling a holistic study of the motivational antecedents and consequences of gaming.

### 1.4 Problematic gaming

Problematic gaming was found to be a major negative influence of video games for some gamers, and it is assumed to be a psychopathological entity of its own, continuously causing problems in a life of an affected gamer. Problematic gaming or "gaming addiction" has a long history and has been first discussed in a paper by Soper and Miller from 1983 entitled "Junk time junkies" (Soper & Miller, 1983). Since then, the research and real-life cases led experts and governing bodies to include it into official disease classification systems. Internet gaming disorder (IGD) was included into DSM-5 as a condition for further study (APA, 2013) and Gaming Disorder was included as a disorder into ICD-11 as a diagnosable disorder (WHO, 2022). Internet gaming disorder (APA, 2013) and Gaming Disorder (WHO, 2022) offer different definitions of problematic gaming because of different symptoms they include, with Internet gaming disorder containing several symptoms that are probably not apt for the context of gaming (e.g., Razum et al., 2023; Castro-Calvo et al., 2021). However, both definitions centre around a pattern of consistent or recurring gaming behaviour lasting for at least 12 months that is manifested by symptoms such as loss of control, continuation of gaming despite experiencing negative consequences and experiencing significant impairment in personal,

family, social, educational, occupational and other areas of functioning. Problematic gamers withdraw into the virtual world and neglect their real-world duties (King & Delfabbro, 2018). According to clinical studies, problematic gaming is associated with significant impairment, such as an impairment in school and work functioning and sleep disturbances (Ko et al., 2020). Many studies that investigated problematic gaming were conducted on adolescents, for example those investigating family factors (Nielsen et al., 2020) and other risk factors (Sugaya et al., 2019), neural correlates (Schettler et al., 2022) and health related outcomes (Männikkö et al., 2020). Such attention is understandable, since although problematic gaming often does not show high stability (Richard et al., 2020) if it starts in adolescence, it could damage a person's educational, developmental, occupational and other perspectives in both short and the long run (King & Delfabbro, 2018). However, problematic gaming affects a very small percentage of (adolescent) gamers. It is assumed that it affects from around 2% (Haagsma et al., 2012; Razum & Glavak Tkalić, 2023) to 8% or more gamers and from 1% to 2% of the general population (Stevens et al., 2020; Kim et al., 2022). Related to this, research on problematic gaming would benefit most when it would be conducted on clinical populations suffering from this condition or on populations that are at high risk of developing Gaming Disorder (Aarseth et al., 2017; van Rooij et al., 2018).

Besides problematic gamers, it is assumed that there is a much larger percentage of gamers (e.g., 15-20+%) who play a lot of hours on a weekly basis, especially in adolescence, do not fulfil the criteria for addiction and enjoy positive consequences from gaming as well. For example, the ESPAD study (The ESPAD Group, 2019) that collected representative data on 99,647 16-year olds in 35 European countries found that 11.6% of all 16-year-olds in Europe and 19.2% of 16-year-old European boys play video games for 4 or more hours on a school day. These numbers are perhaps overblown due to the retrospective bias in reporting gaming time (e.g., Johannes et al., 2021), but they roughly speak about the sheer number of adolescents who play video games intensively. Although research on problematic gaming in adolescence is abundant, research on gaming and well-being and sleep, which would take on a holistic perspective and look at video games as a normal and not an addictive behaviour, is falling behind.

### 1.5 Studies relating gaming to different well-being criteria

Several studies have found that video games are related to factors that may facilitate well-being or to well-being in a broader sense. Games have been found to increase creativity (Granic et

al., 2014), improve adolescent's English language skills, and indirectly influence adolescents' technology skills and career interests (Razum & Huić, 2023; Ball et al., 2020). In a qualitative study, Bourgonjon et al. (2016) have found that games can aid players in their self-development, by letting them experience different perspectives and learn about history and other topics. Studies have found that the first-person shooters improve visual attention (Feng & Spence, 2018), that cooperative multiplayer games improve prosocial behaviour, even if the games in question are violent (Granic et al., 2014), and that strategic games possibly improve problem-solving skills of adolescents (Adachi & Willoughby, 2013).

In a narrower sense of connecting games and well-being, experimental studies have shown that casual video games can decrease tension and improve mood (Russonielo et al., 2009) and that a moderately difficult simulation game can help in alleviating negative mood (Bowman & Tamborini, 2012). Experimental evidence also indicates that playing a puzzle game can reduce the symptoms of depression (Russonielo et al., 2013) and that playing an action game might reduce rumination in depressive patients (Kühn et al., 2018). Qualitative studies have found that games can help gamers cope with mild everyday stress or with more serious stressors (Bourgonjon et al. ; 2016; Iacovides & Mekler, 2019; Razum & Huić, 2023).

These studies, although they spoke about different possible (positive) effects of video games, were often either experimental studies conducted in artificial conditions and focusing on specific types of games, qualitative studies offering different ideas that are yet to be verified in a quantitative study or studies not directly addressing well-being. Moreover, besides Razum and Huić (2023), none of these studies were conducted on adolescents.

Besides these studies, there are also studies attempting to answer a basic question of how gaming time relates to well-being (Vuorre et al., 2022) and sleep in adolescents in general.

### 1.6 Gaming time and well-being and sleep

Gaming time usually refers to either subjectively or objectively measured daily or weekly time a gamer spent playing video games (Johannes et al., 2021). Researchers created different hypotheses about the relationship of gaming time and well-being, some of them predicting negative effects and other predicting positive effects.

Neumann's Displacement hypothesis (1988) states that by using technology, or in this case video games, we are in fact reducing the time we have available for doing other, more useful or healthy activities, such as face-to-face social interactions, sleep or physical activity

(Hartanto et al., 2020). Some studies have indeed found that more gaming time is associated with lower well-being. For example, a study by Maras et al. (2015) conducted on a large sample of Canadian adolescents has found a moderate positive relationship between video game playing time and both depression and anxiety. A study by Hellström et al. (2015) showed positive relationships between gaming time and depression, psychosomatic and musculoskeletal symptoms in adolescents. In contrast to these findings, Király et al. (2017) have shown that gaming time is not related to different psychiatric symptoms and Brunborg et al. (2014) showed no relationship between gaming time and depression and academic achievement in a two-wave study on Norwegian adolescents.

Twenge and Campbell (2019) offered a modification of the Neumann's (1988) hypothesis, stating that light use of technology or in this case video games is beneficial, but well-being drops when moving toward moderate and especially heavy use, which may then activate the displacement mechanism. Twenge and Campbell (2019) have found support for their hypothesis on three large samples of adolescents, where "heavy users" of video games, defined as those who play video games for 5 or more hours a day, had sizeably lower well-being than "light users", defined as those who play for less than hour a day. Przybylski and Weinstein (2017) constructed a similar "Goldilocks" hypothesis, where light to moderate use of video games is not related to well-being, but high use is negatively related to well-being. They have found support for this hypothesis (Przybylski & Weinstein, 2017), but the negative effect of video games that began at high levels of video game use was small.

Finally, according to Adachi and Willoughby (2013) video games satisfy Larson's (2000) criteria for initiative: a) intrinsic motivation, b) concentration and cognitive effort and c) cumulative effort over time to achieve a goal. In that way, they may be similar to other organized activities such as sports and clubs and may aid in positive youth development. Therefore, the relationship between gaming time and well-being could be slightly positive or non-significant.

All studies presented until now have included one simple question about gaming time, and gamers tend to distort and overestimate their gaming time when asked about how much they play in surveys (Johannes et al., 2021). These questions are not easy to answer, since they include larger time periods (e.g., two weeks) and/or ask about gaming time on an "average day". Studies that used objective measures of gaming time or daily diary data lend support to the Adachi and Willoughby's (2013) idea. In a study that used objective measures of gaming

time obtained from gaming companies, Johannes et al. (2021) have found a slightly positive relationship between gaming time and affective well-being. However, this study included only two "casual" video games. A study by Vuorre et al. (2022), which used objective playing data, and included a larger variety of video games and three measurement points, has shown that there is essentially no relationship between gaming time and affective well-being and between gaming time and life satisfaction. Finally, a study by Allen (2020), which used a daily diary design and asked gamers about their gaming time on a daily basis, obtained a slightly positive relation between gaming time and a composite measure of well-being.

Therefore, if we take into account these methodologically more "sophisticated" studies, it seems that the relationship between gaming time and well-being is either slightly positive or neutral, although it is not certain if these findings would generalize to adolescents.

Alongside the hypotheses about gaming time and well-being, several hypotheses exist about the relationship of gaming time and sleep, all considering a negative relationship. Authors (King et al., 2013) thought that video games may disrupt sleep by means of either direct displacement, i.e., by having less time for sleep because of playing video games, by increased mental, emotional or physiological arousal or by the bright light exposure delaying the circadian rhythm. In an experimental study by King et al. (2013), adolescents were invited into the lab and instructed either to play 150 minutes of a violent game before sleep or to play 50 minutes of a non-violent game, and both groups went to sleep at the same time. Objective polysomnography measures have shown that prolonged gaming before sleep decreased total sleeping time by 27 minutes and sleep efficiency by 7% compared to the group that played video games for a considerably shorter period of time. In another study by Wolfe et al. (2014) adolescents were allowed to play video games as much as they wanted before going to sleep in a laboratory. Those who played longer slept less and had lower sustained attention performance on a test performed the following day. However, these studies were conducted in artificial conditions and involved a very small number of participants (e.g., $N$=20). There are almost no studies where the relationship between gaming time and sleep was assessed on a sample of adolescents playing in natural conditions.

Studies on adults show a negative relationship between gaming time and sleep (e.g., Exelmans & van den Bulck, 2015), but these studies were conducted both cross-sectionally and by using self-report. In a more methodologically advanced study by Orben and Przybylski (2019), where adolescents used time use diaries to report on their technology use and sleep for two days, it

was shown that technology use is only weakly negatively related to sleep. All in all, there is some evidence that gaming time is negatively related to sleep in adolescents, but more sophisticated studies which would observe adolescents in natural settings are lacking.

A further extension into the relationship between gaming time and well-being and sleep includes testing for possible theoretically plausible moderators. Moderators were suggested and tested mostly in the relationship between gaming time and well-being. In studies by Johannes and associates (2021) and Allen (2020), no moderator effects were obtained, neither for intrinsic and extrinsic motivation (Johannes et al., 2021), nor for harmonious and obsessive passion, gaming disorder symptoms and traits need satisfaction and frustration (Allen, 2020). A possible moderator that they did not test for is self-control. Self-control was mentioned by Hoffman et al. (2016) as a key possible moderator in the relationship between media use and well-being. No moderators were yet tested in the relationship of gaming time and sleep.

However, even if moderators are included, the mere relationship between gaming time and well-being or between gaming time and sleep is not very informative. It has been shown, for example, that the number of hours played is not a good indicator of problematic gaming or of negative consequences (e.g., Slack et al., 2022; Billieux et al., 2019). Moreover, "highly engaged" non-problematic adolescent gamers who all play many hours per week may be better or worse at incorporating gaming within their lives (Razum & Huić, 2023). An important piece of the puzzle is the gaming motivation.

### 1.7 Gaming motivation or why adolescents play video games

Focusing only on the effects of video games on well-being may only tell half the story. It is important to know why individuals want to play video games, which can also help better understand the effects of video games (Hartanto et al., 2020). Lucas and Sherry (2004; Sherry & Lucas, 2003) applied the Uses and gratifications theory to the domain of video games. This theory was originally developed to conceptualize the motivation to use different types of media, and it states that people use media to solve different "problems", for example some people may watch TV to be entertained or to hear the news. In other words, people are not merely passive recipients of media content, and it is more important to see what the individuals do with the medium than what the medium does to them (Lucas & Sherry, 2004). Sherry and Lucas (2003) conducted qualitative and quantitative research grounded in the Uses and Gratifications theory and uncovered six principal motives for playing video games: competition, challenge, social interaction, diversion (i.e., to pass the time or alleviate boredom), fantasy and arousal. Two

more conceptualizations leaned on the Uses and gratifications theory approach, although they did not explicitly use it. In a quantitative study starting with 40 items, Yee (2006) uncovered three main motivations of players of Massive Multiplayer Online Role-Playing Games (MMORPG), each of which has multiple subcomponents: achievement (advancement, mechanics, and competition), social (socializing, relationship, and teamwork) and immersion (discovery, role-playing, customization and escapism). Demetrovics et al. (2011) have developed the Motives for Online Gaming Questionnaire (MOGQ), which includes seven factors: social, escape, competition, coping, skill development, fantasy and recreation.

Besides these conceptualizations that used or leaned on Uses and gratifications theory, De Grove et al. (2016) created a conceptualization of gaming motives that stems from the Social Cognitive Theory (Bandura, 1986). Following this theoretical approach and conducting qualitative and quantitative research, De Grove et al. (2016) created a questionnaire which measured eight motives: habit, moral self-reaction, agency, narrative, escapism, pastime, performance and social. It can be noticed that, although the questionnaire includes some motives which are similar to those in other described questionnaires, it also includes habit, which refers to playing games out of routine, and moral self-reaction, which refers to the own, social and moral norms about playing video games.

Gaming motives from the described motivational approaches were used to predict gaming time. In a study using Yee's (2006) conceptualization, Williams et al. (2008) have found that the Socialization and Achievement motives were positively associated with gaming time, and the Immersion motive was negatively associated with gaming time. In another study using a more detailed version of Yee's approach (2006), Billieux et al. (2013) found that Advancement, Mechanics, Competition, Relationship and Customisation were related to gaming time. Hesselle et al. (2021) have found that Social, Escapism and Competition motives from the Demetrovic's (2011) MOGQ questionnaire predict greater gaming time, when controlling for personality traits. De Grove et al. (2014) have found that practically all of the motives measured by their questionnaire (Performance, Narrative, Social, Habit, Escapism, Agency and Moral self-reaction) predict the expected play frequency and the average duration of a gaming session.

Although the described motivational approaches are useful in explaining why adolescents and other people play videogames, they deal only with playing video games and do not put them in context with the rest of a person's life. A link between these motivators and well-being and sleep is therefore hard to make because one cannot take into account the effects of these same

motivators in real life on these criteria. As described earlier in the introduction, adolescent well-being is complex and video games are just one of the possible factors that can influence it. Previously described approaches of examining the effects of video games on well-being and sleep lack substantial theory. Specifically, they lack the motivational component and the mechanism through which the games would enact their effects and also lack the context of the rest of a person's life. An adolescent can play a lot of video games and at the same time be well adjusted in the rest of their life or play little video games and at the same time not be well adjusted.

Luckily, there is another motivational approach that may provide all of these elements, including the prediction of gaming time and well-being and sleep of adolescent gamers, while taking into account both gaming experiences and their life outside of video games. This is The Self Determination Theory (SDT; Ryan & Deci, 2017). This theory, or more specifically Basic psychological need theory (BPNT) within it, firstly allows to examine the motivational component, where real-life and in-game psychological needs predict gaming time, which can answer the question of why adolescents play video games. Secondly, it allows to holistically assess the effects of gaming on well-being and sleep, by assessing the joint effects of real-life and in-game psychological needs and gaming time on these criteria. It is the only theory that can simultaneously include predictors from real life and video games, that at the same time predict gaming time, well-being and sleep of gamers. In other words, SDT offers a compelling theoretical mechanism that simultaneously provides the motivational antecedents and predicts the consequences of gaming.

### 1.8 The Self Determination Theory and the Basic psychological need theory

SDT is a broad psychological theory which is "concerned with the nature, structure, and functioning of a person in action, including the person's inherent proactive capacities to selectively engage, interpret, and act on external environments" (Ryan & Deci, 2017, pp. 8). The theory concerns human motivation, personality development and well-being and it is among the most researched and applied theories in psychology (Ryan et al., 2022). Unlike behaviourist theories or the social cognitive theory, it stresses the importance of psychological needs and autonomy (Ryan et al., 2022), and focuses on the degree to which human behaviours are volitional or self-determined.

Specifically, this dissertation will focus on the Basic psychological need theory (Ryan & Deci, 2017), which is the central mini-theory among the six mini theories that are a part of the SDT.

It states that the satisfaction of basic psychological needs: autonomy, competence and relatedness leads to psychological growth and higher well-being, whereas need frustration, which refers to need thwarting, leads to lower well-being and to the development of psychopathology in the long term.

The basic needs are defined as follows. Autonomy is the experience of the volitional and conscious engagement with an activity and self-endorsement of this activity (Vansteenkiste & Ryan, 2013). Autonomy is not just a state of "freedom", nor it is dependent on having a lot of options or on being self-reliant in one's functioning (Ryan & Deci, 2017). It is about seeing real and meaningful opportunities and making real and meaningful choices (Rigby & Ryan, 2011). When a person engages in autonomous behaviours, they are self-endorsed and in congruence with one's authentic interests and values (Ryan & Deci, 2017). Competence is a sense of effectiveness and mastery in one's interaction with the environment. It is an inherent striving which energizes many different behaviours, from leisure behaviours to the most complex job tasks (Ryan & Deci, 2017). The need for competence becomes satisfied when a person engages in activities and experiences opportunities that allow them to use and extend skills and expertise (Vansteenkiste et al., 2020). Finally, relatedness refers to a feeling of social connectedness and people often experience it when they feel that others care for them (Ryan & Deci, 2017). At the same time, relatedness is equally about belonging and care that we show for other people. It can also be experienced through acknowledgement that we gain from others (Ryan & Rigby, 2011) and by being a significant member of social groups (Ryan & Deci, 2017). Relatedness can be experienced through very subtle actions, for example when we get recognized by a clerk in a store.

During the years of research on SDT, it was noticed that the lack of need satisfaction is not sufficient to explain the dark side of human condition. A construct which would capture more intense negative need experiences was needed and thus a new dimension of need frustration was created (Warburton, 2020). Unlike the lack of need satisfaction, need frustration relates to the thwarting of basic psychological needs within social contexts. The relationship between the two dimensions of need satisfaction and need frustration is thought to be asymmetric, meaning that low need satisfaction does not have to assume high need frustration, whereas high need frustration by definition involves low need satisfaction (Vansteenkiste & Ryan, 2013). Vansteenkiste and Ryan (2013) give an example of feeling low relatedness in a workplace as a consequence of not having enough social contact and subsequently feeling less vitality for work (lack of need satisfaction). This is contrasted to being actively rejected by the co-workers

(relatedness need frustration) and consequently suffering from severe stress and possibly depression. Other needs besides relatedness can be frustrated as well. Competence is thwarted within environments where challenges are too difficult, negative feedback is abundant and mastery and effectiveness are undermined by factors such as person-focused criticism and social comparisons (Ryan & Deci, 2017). Autonomy is frustrated when a person experiences pressure and conflict and can feel as if they are being pushed to do something they don't want to (Vansteenkiste et al., 2020). To further illustrate the difference between (low) need satisfaction and need frustration, Vansteenkiste and Ryan (2013) use the example of growing plants. If a plant is not given enough sunshine and water (low need satisfaction), it will not grow and will die over time. However, if salted water is thrown at the plant (need frustration), it will wither more quickly.

Satisfaction and frustration of psychological needs are the crucial ingredients of our well-being and have shown to relate to sleep as well. Cross-sectional studies have shown that the satisfaction of basic psychological needs in adolescents is connected to higher life satisfaction and positive affect (Rodriguez-Meirinhos et al., 2019), to a composite of positive and negative affect (Thomaes et al., 2017), as well as to lower physical symptoms and higher vitality (Reinboth et al., 2004). A daily diary study (Thomaes et al., 2017) has shown that on days when adolescents experience an above average satisfaction of psychological needs, they also have an above average life satisfaction and higher scores on a composite of positive and negative affect. On a sample of adolescent football players who were measured six times over two seasons, it was shown that satisfaction of competence and relatedness needs predicted within person changes in vitality (Adie et al., 2012). Conversely, psychological need frustration was usually used and found to predict negative mental health outcomes in adolescents, such as depression (Costa et al., 2016), and externalizing and internalizing problems (Rodriguez-Meirinhos et al., 2019), which were not predicted by psychological need satisfaction. In the context of well-being, a daily diary study (Laporte et al., 2021) has shown that psychological need satisfaction in adolescents is related to the positive affect and weakly related to the negative affect experienced on that day, whereas psychological need frustration is related to the negative affect. In a meta-analysis conducted on adult samples, Stanley (2021) has found that psychological need satisfaction is connected to both positive and negative affect, but they did not include findings concerning the need frustration.

Multiple studies investigated the relationship between psychological needs and sleep. Cross sectional studies conducted both in community samples (Campbell et al., 2015) and on samples

of persons with severe sleep problems (Campbell et al., 2017) have shown that need frustration relates to self-reported poorer quality of sleep. In a two-wave study, Uysal et al. (2020) have shown that psychological need frustration predicts worse sleep quality and quantity two years later. In another two-wave study, Tavernier et al. (2019) have shown that need satisfaction predicts higher sleep duration in university students, but only during the weekend. However, there has been only one diary study that was able to access within person relationships and this study was also the only study conducted on adolescents. In a study by Campbell et al. (2021), it was found that need satisfaction and frustration experienced during a day predicted objective and subjective sleep on the following day via stress and fatigue. In one model, need frustration had a direct negative relationship with subjective sleep.

All in all, the effects of psychological need satisfaction on different well-being indicators have been established in adolescents, but studies are still lacking which would examine these relationships on a daily, within-person, level. Such studies are even rarer with regards to need frustration, especially studies which would examine the relationship of psychological need satisfaction and frustration to well-being criteria on adolescents simultaneously in a single study. The relationship between need satisfaction and frustration and sleep in adolescents was tested only in one study.

Psychological needs can be satisfied in different contexts, such as sport activities (Erdvik et al., 2020) and school contexts (Tian et al., 2013), and video games are one of those contexts as well. As mentioned in the previous chapter, what makes the SDT so appealing in studying video games is that it allows to simultaneously assess the satisfaction of needs in real-life and video games, investigate their motivational role in playing video games, and compare their contribution to well-being and sleep.

### 1.9 Video games and basic psychological needs satisfaction and frustration

Videogames are environments that offer opportunities for the satisfaction of all three needs. Games that satisfy the need for autonomy offer choice over movement and strategies, as well as choice over task and goals undertaken, and rewards within them are not meant to control the player's behaviour (Ryan & Rigby, 2011). Games that satisfy the need for competence have intuitive game controls and tasks within them provide apt challenges and possibilities for positive feedback (Ryan et al., 2006). Videogames can also satisfy the need for relatedness. In single player games, players interact with so called "non-player characters" (NPC's), who are other characters in the game that are controlled by it. They can express gratitude for helping

them or help us when we are in trouble (Rigby & Ryan, 2011). In multiplayer games, the need for relatedness can be satisfied through cooperation with other players and overcoming challenges together, but also through talking to others. It could be argued that online games could in some cases even offer a more profound satisfaction of the need for relatedness than in real life, e.g., given that the anonymity of the virtual world facilitates open and intimate conversations (Kaye & Kowert, 2018).

A game can satisfy one or more needs, and in fact the most successful and acclaimed games satisfy multiple needs (Rigby & Ryan, 2011). For example, a very popular contemporary game Counter Strike: Global Offensive satisfies competence through playing against a team of characters controlled by other players which increases the challenge level, relatedness through playing together with teammates and autonomy through designing and testing new strategies.

Besides need satisfaction, video games can bring need frustration as well. Although it is assumed to be a rarer experience, since the developers often indirectly or directly try to create gaming experiences that would satisfy psychological needs (Rigby & Ryan, 2011), need frustration can still happen within games. Competence need frustration happens when the games are too difficult to learn and play for players (Przybylski et al., 2014). This can happen because of factors such as non-intuitive game controls or because the game is overly challenging (Przybylski et al., 2014). In multiplayer games, competence frustration could relate to playing against too strong opponents. Like in real life, it could also relate to person-focused criticism received from teammates and to social comparisons of ability and rating between players. Autonomy frustration happens when games do not allow for choices over movement and strategies, tasks and goals. Players may feel as if they are pushed to do things they did not choose to do by either the game or by their teammates. Finally, relatedness frustration may happen when players feel rejected by either the non-playing characters or by other players within the game.

Research conducted until now has demonstrated that not only real-life psychological need satisfaction and frustration, but also in-game psychological need satisfaction and frustration, are related to well-being.

There are multiple studies showing that in-game need satisfaction predicts well-being. Ryan et al. (2006) have shown in an experimental study that game exposure by itself decreases vitality by making participants tired, but if psychological needs are satisfied in-game, vitality will increase. Sheldon and Filak (2008) manipulated autonomy, relatedness and competence need

support in a puzzle game by giving instructions that were supposed to either foster or not foster the satisfaction of these three needs in subsequent gameplay. Relatedness and competence satisfaction while playing the game were positively related to positive and negatively related to negative affect in participants. Johannes et al. (2021) have shown in a cross-sectional study that in-game need satisfaction is connected to higher well-being, defined as a composite formed of positive and negative affect. In another cross-sectional study, Kosa and Uysal (2022) have shown that in-game need satisfaction is positively related to vitality. Additionally, Allen (2020) has demonstrated that in-game need satisfaction on a daily level predicts well-being, defined as a composite formed of positive and negative affect, life satisfaction, vitality, physical symptoms, and self-esteem, above the need satisfaction in real life. The one exception is the study from Bender and Gentile (2020), who have shown in a cross-sectional study that in-game need satisfaction is connected to Gaming Disorder symptoms. Despite several conducted studies, Allen's (2020) study is the only study that examined the relation between in-game satisfaction and well-being on a daily, within person, level, and in a natural setting, but it was conducted on adults and not on adolescents. Additionally, well-being was defined differently in different studies, often as a composite variable, and it is not clear how in-game need satisfaction affects different components of well-being.

Regarding in-game need frustration, Allen and Anderson (2018) have found that it is negatively related to a composite measure of well-being only with regards to autonomy frustration. Kosa and Uysal (2022) have shown that in-game need frustration is negatively related to vitality, but this relationship was weaker than the positive relationship between in-game need satisfaction and vitality. In Allen's (2020) daily diary study, in-game need frustration was not related to a composite well-being measure, and the author speculated that this is because there was not much variation in the daily in-game need frustration that the gamers experienced, i.e., their in-game needs were mostly not frustrated. In an experimental study, Przybylski et al. (2014) have shown that in-game competence frustration (when games are too difficult or not intuitive) leads to postgame aggressive feelings, a higher accessibility of aggressive thoughts and a higher probability of enacting aggressive behaviours, and that this effect is independent of whether video games have violent content or not. To sum up, both real-life and in-game need satisfaction and frustration seem to predict well-being. In-game need satisfaction is positively associated with vitality, positive and negative affect and well-being composite measures. In-game need frustration was found to be negatively related to vitality and a composite well-being measure or not to be related to well-being at all. Unlike these studies that dealt with well-being,

there were no studies that examined the relationship between in-game need satisfaction and frustration and sleep.

Besides predicting well-being and sleep, in-game and real-life need satisfaction and frustration should also predict gaming time. This speaks of the motivational component of psychological need experiences. Namely, experiencing either psychological need satisfaction or need frustration while playing video games should increase or decrease the motivation to play and thus increase or decrease the gaming time. Alongside the in-game need experiences, real-life need experiences could also influence gaming time.

In-game need satisfaction should act as a motivator and increase gaming time, because gamers should like to play games that satisfy their psychological needs. Research conducted until now has supported this prediction. Tamborini et al. (2010) have shown in an experimental study that in-game need satisfaction explains 51% of variance in game enjoyment and that it has an incremental contribution in predicting game enjoyment over game arousal and absorption (Tamborini et al., 2011). In another experimental study, Ryan et al. (2006) have shown that in-game need satisfaction leads to higher motivation to play the game and longer playing times. Three cross-sectional studies investigated the relationship between in-game need satisfaction and weekly playtimes (Johnson et al., 2016; Allen & Anderson, 2018, Mills et al., 2018) and it was shown that weekly playtimes are predicted by the satisfaction of each need independently (Johnson et al., 2016; Allen & Anderson, 2018) or by a composite of those needs (Mills et al., 2018), even when controlling for other potential predictors of playing time (Johnson et al., 2016). Finally, Quist (2016) has shown in a diary study that in-game need satisfaction is connected to longer playing times. However, none of these studies were conducted on adolescents.

In-game need frustration is a more under-researched construct than in-game need satisfaction (Kosa & Uysal, 2022). Its relationship with gaming time was not investigated in any of the studies, although it can be assumed that it would decrease the gaming time because it is an unpleasant and demotivating experience.

Finally, besides in-game need satisfaction and frustration, their real-life counterparts were used to predict gaming time as well. The relationship between real-life need frustration and gaming time is theoretically intriguing, since SDT assumes that need frustration in life can yield compensatory behaviours (Vansteenkiste & Ryan, 2013) and this may mean turning to video

games. According to Ryan and Rigby (2011), satisfaction of needs is often readily available in video games (immediacy), virtual worlds are more predictable than the real world (consistency) and needs can be satisfied usually much faster than in real life (density). In other words, if gamers have their needs frustrated in real life, they might turn to videogames as a readily available, quick, and reliable source of need satisfaction. This idea was named the "need-density hypothesis" (Ryan & Rigby, 2011). Kardefelt-Winther (2014) theorized that this mechanism is not necessarily pathological, in a sense that it can be natural to seek virtual satisfaction of a need unmet in real life, but this may lead to negative consequences in the long run. In any case, it could be assumed that need frustration in real life could act as an additional motivator which would increase gaming time. As a continuation of this idea, experienced real-life need satisfaction could decrease gaming time since the needs are already satisfied in real-life.

Real-life needs frustration was shown to be positively related to gaming time in several studies, which would indicate that players use games as a compensatory mechanism for satisfying their needs (e.g., Mills et al., 2018a; Mills & Allen, 2019). However, these findings were obtained in cross-sectional studies. At the within-person level, in a longitudinal study with five measurements, Mills et al. (2018b) have obtained a negative relation between real-life need frustration and gaming time for males and no relation for females. In diary study, Allen (2020) obtained a similar finding for the entire sample: real-life need frustration was negatively related to gaming time; that is, the more real-life need frustration gamers felt within a day, the less they played on that day. Regarding real-life need satisfaction, one daily diary study found a positive relationship between need satisfaction and video game playing time (Quist, 2016), although it did not separate real-life and in-game need experiences.

If we consider all the reviewed research about need experiences, gaming time, well-being and sleep, several main conclusions can be drawn. Firstly, studies have shown that gaming time is positively predicted by in-game need satisfaction and there are no studies connecting in-game need frustration and gaming time. There are mixed results about real-life need frustration predicting gaming time, but studies that have examined within-person relationships point to a negative relationship that is contrary to the theoretical predictions. One study connecting real-life need satisfaction and gaming time points to a positive relationship, which would also be contrary to the theoretical prediction.

Secondly, studies have shown that well-being, in terms of positive and negative affect and vitality, is predicted by real-life need satisfaction and by real-life need frustration, although there are more studies involving real-life need satisfaction. These studies were also conducted on adolescents. In-game need satisfaction predicted well-being in several studies, defined as vitality or a composite variable. There were mixed results regarding in-game needs frustration, with some studies showing a negative relationship with well-being and one study showing no relationship. Sleep was only related to real-life need frustration in one study, and no studies investigated the relationship of sleep with in-game need satisfaction and frustration.

Finally, as mentioned in previous chapters, relationship between gaming time and well-being and sleep was investigated in multiple studies. Although there are studies that show a negative relationship between gaming time and well-being, methodologically more "sophisticated" studies point to an either neutral or slightly positive relationship between gaming time and composite well-being measures. Studies investigating gaming time and sleep point to a negative relationship, although there are studies that suggest that this relationship could be small in magnitude.

Most of the studies mentioned in this review were not conducted on adolescents and studies rarely examined need experiences in real-life and in video games simultaneously (e.g., Allen, 2020), taking into account both of these contributors to gaming time and especially to well-being. None of the reviewed studies considered the contribution from need experiences to well-being when assessing the relationship between gaming time and well-being. A study is needed which would be conducted on adolescents and consider a) the contribution of both real-life and in-game need satisfaction and frustration when predicting gaming time, and b) the contribution of need-based experiences and gaming time when predicting well-being and sleep. In such a way it is possible to adequately assess the individual contributions from real-life and in-game need experiences to gaming time, and contributions from need experiences and gaming time to well-being and sleep.

### 1.10 Methodological considerations in SDT research of video games

Besides the theoretical issues, the field researching antecedents and consequences of gaming has issues with conclusions that could be drawn via implemented research designs and with the measurement of relevant constructs. Research of antecedents and consequences of gaming within the SDT framework has often neglected these issues and defaulted to cross-sectional

designs, unclear operationalizations of the well-being criteria and inadequate forms of self-report measurement of gaming time and sleep.

In the following section, I will review the methodological approaches used so far in the SDT research of antecedents and consequences of gaming and discuss previous findings in the light of the inferential limitations that the used research designs impose. I will discuss the intensive longitudinal design as a possible alternative.

### 1.10.1 Research designs used in gaming research within the SDT framework

Gaming research within the SDT framework has often been conducted by using the cross-sectional design. This design can be useful when trying to establish covariation between the variables at early stages or when trying to rule out alternative explanations at later stages of research (Spector, 2019). Similarly, it can be used to test for moderation effects, for example as in the study by Allen (2020), where they examined how gaming disorder symptoms and harmonious and obsessive passion interact with gaming time in predicting well-being. However, the cross-sectional design cannot establish the temporal precedence of variables (Spector, 2019) and, like all non-experimental designs, it has the "third variable" problem, meaning that both predictor and the criterion can actually be caused by an unknown third variable. Moreover, cross-sectional results are an inseparable mixture of between person stable differences and within person changes, which is also the case in longitudinal studies when they don't have at least three measurement points (Hamaker, 2012; Hamaker et al., 2015). Although cross-sectional studies can provide initial evidence, they cannot examine the within-person trends over time that we are usually interested in. For example, as already mentioned, it was found that in-game need satisfaction is connected to longer playing times (Johnson et al., 2016) and to higher scores on a composite variable including positive affect and inversely coded negative affect (Johannes et al., 2021). However, these cross-sectional results do not mean that when a person achieves higher in-game need satisfaction, they will play more and experience higher well-being. They should only mean that those people who experience higher in-game need satisfaction also on average tend to play more and experience higher well-being. This and any other cross-sectional result is interpreted as a between person stable difference, but we cannot even be sure about this interpretation since, as already mentioned, this result is in fact a mixture of between person stable differences and within person fluctuations that occur on the day the measurement took place (Hamaker, 2012). Adding to this the problems of temporal

precedence and third variables, these results can give us only the initial evidence about the connection of in-game need satisfaction and gaming time and well-being.

Longitudinal studies or studies with multiple measurement points are usually used to answer such research questions, and they are scarce in gaming research conducted within the SDT framework. A study by Mills et al. (2018b) examined relationships between passion for gaming, needs frustration and gaming time, while using one baseline measurement and five additional measurements conducted every two weeks. As already mentioned, they found that there is a negative relationship between real-life need frustration and gaming time for males and no relationship for females. Unlike a cross-sectional or a longitudinal study with less than three time points, a within person relationship was assessed in this case. This relationship should mean that on those fortnights when males felt above average need frustration they played video games below their average. And while such studies provide valuable evidence, they also have flaws. Namely, it is very hard to be sure that we correctly defined the causal lag during which the cause is supposed to affect the outcome (Spector, 2019). In gaming research within SDT, causal lags are (still) not known and using the longitudinal design can therefore produce distorted results. In the mentioned study by Mills et al. (2018b) the measurements were separated by two weeks and it is possible that need frustration affects gaming time on a day to day time scale. The effect that is obtained when measurements are separated by two weeks, or by multiple months as it is customary in longitudinal research, could be incorrectly assessed if the real process occurs on a shorter time scale.

Experimental designs are causally superior to cross-sectional and longitudinal designs and are sometimes used in gaming SDT research as well. In already mentioned series of studies, Ryan et al. (2006) let participants play different games in a laboratory and examined if higher autonomy and competence satisfaction they experienced within the game would lead to higher post-play enjoyment, mood, vitality, and preference for future play. Tamborini et al. (2010) assigned participants to either play a bowling game with a regular controller or with a bowl-shaped controller and to either play with a computer or with a real partner. They then measured how assignment to one of these conditions influenced participants' psychological within-game need satisfaction and how this need satisfaction was in turn related to game enjoyment. In an already mentioned experiment, Przybylski et al. (2014) let one half of the participants play a game with intuitive controls and other half played a game with difficult controls to induce need frustration. They then compared the groups with regards to aggressive feelings and behaviour. These experimental designs enabled establishing a causal connection between need

experiences and well-being or related criteria, especially the studies by Tamborini et al. (2010) and Przybylski et al. (2014), in which need satisfaction was explicitly manipulated. Namely, only in experiments can one control for all the possible "third variables" that can confound the relationship between two variables. However, these studies were still conducted within laboratories, where players played videogames under artificial conditions. Field experiments increase the ecological validity, but they offer less experimental control, and they still involve a manipulation that may be artificial. Roque and Boot (2018) also highlight that participant expectations can weaken the internal validity of experiments involving video games. Namely, it was shown that participants can guess that the experimental condition they are assigned to is expected to yield certain effects, if they are for example playing a certain type of video game or a certain manipulation is carried out. Another problem is the fact that the intervention should exert its effects on, in this case well-being, exclusively through in-game need experiences, and not through some other means, which is not easy to prove (Spector, 2019) because it is not easy to prove that our manipulation induced only e.g., need satisfaction and not some other experiences as well.

Qualitative studies encompass a different research paradigm, where researchers try to answer the questions "what" and "how", understand how people perceive things, understand processes and generally study sensitive or complex issues that are not always accessible to quantitative methodology (Silverman, 2018). Very rarely was gaming investigated qualitatively within the SDT framework or generally in terms of motivation and effects of gaming. For example, Razum and Huić (in review) examined what motivates adolescent gamers to play and how they integrate video games within their lives. One of their findings was that gamers tend to be mindful of their sleep, i.e., on school days they will mostly try to get enough sleep. This was an interesting insight, but the authors could not test it quantitatively, for example by testing the actual relationship between gaming time and sleep. However illuminating the results of these studies might be, they still cannot answer the variable-oriented questions that we are interested in when applying the SDT to gaming behaviour. Another possibility is to supply the qualitative data with quantitative data within the same study, in a so-called mixed methods design. Hoffman and Nadelson (2010) used a cross-sectional survey in addition to their qualitative data about gaming motivation. Although these studies can be very rich in data that they provide, the aforementioned shortcomings apply for both their quantitative and qualitative parts.

### 1.10.2 Intensive longitudinal designs and their advantages in gaming research

As we have seen in the previous paragraph, the cross-sectional studies, longitudinal studies, experimental studies, and qualitative studies can help us gain important insights into gaming behaviour within the SDT framework. However, they all have their own flaws. The intensive longitudinal design may help mitigate some of these flaws.

*Intensive longitudinal designs*[1] are an umbrella term encompassing designs that, according to Bolger and Laurenceau (2013, pp.2) "involve sequential measurements on five or more occasions during which a change process is expected to unfold within each subject (e.g., person or other sampling unit)". They have many names in literature: experience sampling, daily diary studies, interaction records, ecological momentary assessment, ambulatory assessment, and real-time data capture, and all these designs share fundamental similarities. The intensive longitudinal designs provide some key benefits over the previously elaborated quantitative designs.

As mentioned, relationships obtained in cross-sectional studies and in longitudinal studies with less than three measurement points offer a mixture of between person and within person variance (Hamaker, 2012). Even if those relationships would be fully between person, they would mean that, for example, those who experience more in-game need satisfaction would also have a higher well-being on average. In contrast, a within person relationship would in this case mean that on days when gamers experience higher in-game need satisfaction than their daily average, they would also experience well-being higher than their daily average.

Within-person relationships between variables do not necessarily have to be the same as the between-person ones (Curran & Bauer, 2011). As it was already mentioned, it is possible that at the between person level, those who feel higher real-life need frustration would on average play more video games. However, at the within person level, on days when a person feels higher need frustration, they would actually play less video games.

[1] Not all researchers would agree with this classification. For example, some understand intensive longitudinal data as the data which is collected on many measurement occasions (e.g., 50 or more) and analysed by methods such as time series and dynamic SEM (Hamaker & Wichers, 2017). However, this classification is useful for conceptualizing these types of designs and separating them from the traditional longitudinal designs.

Psychological theories usually describe within person relationships rather than between person covariation in traits, and intensive longitudinal methodology enables us to test their predictions more adequately in a natural setting. Furthermore, in the case of within person relationships in intensive longitudinal designs, the person is used as their own control (Bolger & Laurenceau, 2013), and between person confounders (e.g., age, gender, personality traits) do not have an influence on these relationships (Gabriel et al., 2018). However, within person "third variables" can still pose problems, and causality cannot be established.

A significant advantage over both the cross-sectional and the "classic" longitudinal designs is the reduction of retrospective bias that the intensive longitudinal designs offer (Beal & Weiss, 2003). Surveys routinely ask participants to reflect on past behaviours or states and to give estimates of their behaviour or feelings while considering a large time frame (e.g., last year). These reports are biased by the processes of episodic and semantic memory. Participants tend to give greater weight to recent or more salient events in shaping their answers and the current mood state can also influence these processes (Beal & Weiss, 2003). Peoples' summaries of their states, experiences and behaviours are poor reproductions of these states, experiences and behaviours. Intensive longitudinal designs significantly reduce these biases by assessing experiences as they happen or over a much shorter period (e.g., daily). In SDT research on gaming, this advantage means that we can get less biased estimates of psychological need satisfaction and frustration, well-being, as well as gaming time.

This advantage is especially useful when assessing gaming time, as this is an indicator that has an objective value that we want to get as close to as possible, and it would be very hard to measure it directly (more about this will be written in the paragraph about measurement).

Same as intensive longitudinal designs, experimental designs also examine within-person relationships and usually avoid the retrospective bias because they measure variables in the current moment. On top of that, they can assess causal relationships. However, an advantage of intensive longitudinal studies over experimental designs is the higher ecological validity (Wilhelm et al., 2012). The intensive longitudinal studies measure the behaviour of participants in their everyday life and not in artificial laboratory conditions. Namely, to enact experimental manipulation, we must assign participants to play specific games, while in real life participants choose their own games to play. The artificial conditions in labs can also considerably differ from real life, where gaming "coexists" will all other activities within a person's life. Therefore,

the intensive longitudinal studies offer results that can hold in real life, and not just in laboratories.

The intensive longitudinal design has an important shortcoming that needs to be mentioned. When assessing gaming behaviour, we are also interested in the long-term effects of, e.g., need frustration on gaming time or gaming time on well-being. By choosing the longer time lags in a "classic" longitudinal design, we might get a shot at assessing these effects. However, if we are not sure how these effects unfold, and it is plausible that they first occur at the daily or hourly level and then accumulate over time, by specifying the time lag at an arbitrary value of e.g., 6 months, we run into risk of missing the real change (Spector, 2019). In that case, the effect estimates will be distorted. With the intensive longitudinal design, it is also possible that the effects occur at a more molecular level than the one chosen, but the specification error would in that case be smaller. A possible solution to both acknowledging the scale on which the process unfolds and assessing the long-term effects would be to combine the intensive longitudinal design with the classic longitudinal design with longer lags. In this way we could attempt to assess both short-term and long-term effects, although such a study would require considerable resources.

### 1.10.3 Choosing the right intensive longitudinal design

To sum up, intensive longitudinal designs can assess within person effects in natural settings, on a time scale that is closer to how processes operate and with less retrospective bias while using the person as their own control, which sets them apart from other designs in the context of gaming research. There are different types of intensive longitudinal designs that can be considered.

Generally, three different types of intensive longitudinal designs exist according to Bolger and Laurenceau (2013). These are interval-contingent designs, where participants record experiences at regular and predetermined intervals (prototypical designs are daily process studies and ambulatory assessments); signal-contingent designs, where participants report momentary experiences when prompted by a researcher signal either at fixed or random intervals (experience sampling and ecological momentary assessment designs); and event-contingent designs, where participants answer every time a predefined event takes place.

In intensive longitudinal studies in general, design choice is constrained by the included constructs. This is also the case when researching the antecedents and consequences of gaming within the SDT framework. Measuring gaming time would require that gamers report their total daily gaming time, ideally at the end of the day. Additionally, when answering questions about in-game need satisfaction and frustration, gamers should answer them either while playing video games, which would interrupt them, or at the end of the day when they have finished with playing video games. Participants could therefore hardly be expected to answer to items at random intervals, because they would not necessarily play video games during a random interval in a day. Also, measuring sleep needs to occur only once a day, ideally in the morning. To capture the total daily gaming time, to not interrupt gaming and to capture sleep, it is necessary to use the interval-contingent design, where participants report their experiences at regular and predetermined intervals, namely in the morning for sleep and at the end of the day for other variables.

Finally, choosing the appropriate research design also involves the important question of compliance, since if the participants fill out only a small percentage of their daily surveys, it is not possible to analyse the data and draw conclusions.

This design with two measurements per day and a presumably larger number of items, should not pose problems for compliance, according to two meta-analyses. Namely, they show that the number of questionnaire items generally does not decrease compliance, and it is only the short intervals between the successive measurements that were shown to decrease it (Vachon, et al., 2019; Jones et al., 2019). These meta-analyses were conducted on adults with psychiatric disorders, not on healthy adolescents. However, it has been shown that adolescents can answer a relatively large number of daily questions with high compliance. For example, in an experience sampling study about social media use and friendship closeness conducted on adolescents by Pouwels et al. (2021), adolescents filled in a survey consisting of 23 items six times per day for 21 days. Moreover, in a study by Santiago et al. (2017) on stress, coping and mood in adolescents, the adolescents filled in a survey of 68 items every day for seven days.

Finally, besides the issue of the appropriate design, measurement of the used constructs is also a crucial issue in SDT research on antecedents and consequences of video gaming. As mentioned before, unclear or narrow operationalizations plagued the measurement of well-being, and inadequate measures were used in measuring gaming time and sleep.

### 1.10.4 Measurement of well-being, gaming time, and sleep

Well-being is a complex construct that can be conceptualized and operationalized in multiple ways, and gaming time and sleep are objective behaviours, which can still be measured in multiple ways. Well-being was often defined as an unclear composite or only a certain facet of it, such as vitality, was used in research about the antecedents and effects of gaming. Using clearly defined multiple elements of well-being instead provides more potential for nuanced conclusions. Although gaming time and sleep are objective behaviours, there is no perfect way to measure them. It is important to define which operationalizations are used and with what purpose (Flake & Fried, 2020) to enable drawing appropriate conclusions.

### 1.10.5 Measuring well-being

In gaming research within the SDT framework many constructs were labelled as "well-being". For example, Allen and Anderson (2018) used life satisfaction, loneliness (reversed), self-esteem, psychological well-being, physical well-being and relational well-being all together as a composite measure of well-being. Conversely, Johannes and Vuorre (2021) measured the affective well-being via the positive and negative affect. Gaming researchers do not always refer to their chosen operationalization of well-being while interpreting their results nor do they refer to the operationalizations of well-being used by other researchers while interpreting their results (e.g., Przybylski & Weinstein, 2019), although this does have a bearing on the interpretation. As mentioned previously in the introduction, well-being belongs to "positive mental health", and can be divided into hedonic and eudaimonic well-being. A widely accepted model of hedonic well-being is the already mentioned Diener and Emmons's (1984) model, where well-being consists of life satisfaction, positive, and negative affect. Life satisfaction is considered to be a more stable component of well-being, while positive and negative affect are considered to vary more and are often used as measures of well-being in diary studies using the SDT theoretical framework and/or investigating the effects of technology (e.g., Ryan et al., 2010; Wenniger et al., 2019; Johannes et al., 2021). Eudaimonic well-being does not have a widely accepted conceptualization (Disabato et al., 2016). Ryff's (1989) model, which was mentioned earlier in the introduction, also includes factors that correspond to psychological needs (i.e., environmental mastery, positive relationships, autonomy) which makes it conceptually unclear. Ryan and Frederick's (1997) construct of vitality is another operationalization of eudaimonic well-being, that stems directly from the SDT theory, and was often used in cited gaming research utilizing the SDT theoretical approach. Vitality was defined as "one's conscious experience of possessing energy and aliveness" (Ryan & Frederick, 1997,

pp.530), which reflects not the objective energy levels but a subjective feeling of being energized, invigorated and "alive". It was shown to be related to life satisfaction, positive and negative affect, while existing as a separate construct (Ryan & Frederick, 1997). Besides the psychological dimensions, different authors propose that well-being also encompasses physical wellness or physical symptoms, which emerges as a distinctive factor (Pontin et al., 2013; Ryan et al., 2010). Although they are not explicitly defined like that, physical symptoms may fall under the hedonic well-being since they involve the avoidance of pain.

Besides the hedonic and eudaimonic well-being, that refer to one's general sense of well-being, well-being could be assessed as directly related to gaming. These effects can be positive or negative. Both types of effects should be experienced daily or almost daily, should be noticed by the participants, and should not be covered by hedonic and eudaimonic measures of well-being. For example, shaping one's career interests is not something that occurs daily and feeling happy, sad or energized because of gaming is already included in the hedonic and eudaimonic measures of well-being. Besides, asking participants if they were happier because of gaming, instead of just measuring gaming and happiness separately, could incur bias. However, there are effects that do not fall under this category and can be assessed by participants and generally, a subjective feeling that gaming on a given day brought positive and/or negative effects to a person, is relevant. This could be especially relevant in the domain of negative effects, where the previously mentioned construct of problematic gaming or (Internet) Gaming Disorder (APA, 2013; WHO, 2022) is dominant. This construct, although important, assumes a persistent and maladaptive pattern of behaviour that lasts for at least a year. In other words, by definition this is a construct that probably varies over larger period of time than daily. Its meaning is also often unclear, especially when using the DSM-5 conceptualization (Razum et al., 2023). Measuring just the negative consequences is probably more focused and the meaning of this operationalization is clearer. Van den Eijnden et al. (2022) recently presented a study at the International Conference of Behavioural Addictions (ICBA) in Nottingham where they used similar questions in assessing negative effects of smartphone use, which shows a small trend in using constructs that are more narrowly focused on the negative consequences of technology use.

To sum up, besides the positive and negative affect that are often used measures of hedonic well-being, vitality is a useful measure of eudaimonic well-being. All these measures were extensively used, validated and brought into connection with the SDT theory. Physical symptoms are an additional measure which captures the physical aspect of well-being. Positive

and negative consequences of gaming represent gaming-related well-being and enable measuring the subjective effects of gaming that cannot be captured by the general well-being measures and are more focused than problematic gaming in the case of negative effects.

Unlike well-being, gaming time and sleep are seemingly more straightforward constructs since they refer to behaviours that can be measured objectively. However, their measurement is not straightforward, especially since objective measures can be expensive and/or hard to implement and daily self-reporting can provide a viable alternative.

### 1.10.6 Measuring gaming time

Gaming time can be measured as self-report or via objective indicators of behaviour. Self-report measurement of gaming time was often conducted via just one item (e.g., How many hours and minutes have you played in the past two weeks?; Johannes et al., 2021). In this case gaming time estimates of participants were distorted, for example Johannes et al. (2021) have showed that when asked a question about their average daily playing time of a certain video game, participants overestimate it by on average 0.5 to 1.6 hours. A better operationalization is the adaptation of the General Media Habits Questionnaire (Gentile et al., 2004), which was successfully implemented in several studies (e.g., Mills & Allen, 2019). In this questionnaire, gamers answer for how many hours have they played video games in four blocks of time: 6 am to noon, noon to 6pm, 6pm to midnight, and midnight to 6am. This assessment is probably subjected to distortion as well, but if this question is asked every day, the retrospective bias could be reduced, and the assessment could be more accurate. An alternative is the objective assessment of gaming time, which can be done in several ways. Firstly, data could be obtained from the gaming companies (e.g., Billieux et al., 2013; Vuorre et al., 2022). Even if one manages to cooperate with a video game producer, data can be obtained for only one video game per person, and adolescents usually play multiple games simultaneously (Razum & Huić, 2023). Billieux et al. (2013) obtained data for World of Warcraft players, who usually focus solely on this game, but obtaining data for a similar game that some adolescents devotedly play nowadays would likely restrict the sample to just this, likely very small, portion of adolescent gamers. Secondly, data could be obtained from Steam; however, all participants would have to be users of the Steam platform, and Steam provides only total playing time for the last two weeks, which is often not correct due to different technical issues (StackExchange, 2011). Finally, objective playing data could be obtained if participants installed a tracking app on their computers (e.g., an open-source app *Procrastitracker*) and if they sent the data to the researcher

once the study is finished. However, this poses ethical concerns, especially when the participants are adolescents, because the researcher would be able to see all the other activities that participants were engaged in on their computers. Also, some participants share their computers with their parents or siblings or they play on consoles.

There is therefore no perfect solution for measuring gaming time. While measuring gaming time via a diary study is not perfect, it potentially includes all adolescent gamers, and poses the least ethical and technical concerns.

Besides gaming time, sleep is also an objective behaviour that can be measured either via self-report or via objective indicators. When measuring sleep via self-report, questions are used to assess sleep quantity and sleep quality. In cross-sectional studies and classic longitudinal studies, sleep quantity is assessed by asking the participants at what time do they usually go to bed and wake up (e.g., Exelmans & van den Bulck, 2015), and sleep quality is assessed by questionnaires, such as the Pittsburgh sleep quality index (Buysse et al., 1989). Since sleep varies daily (e.g., Lehrer et al., 2022), such measurement incurs bias. When sleep is measured via diary studies, sleep quantity and sleep quality are assessed on the morning after a person wakes up, which incurs the least possible amount of bias that can be achieved when measuring via self-report. The "gold standard" in measuring sleep is polysomnography, where participants are connected to a device which measures their sleeping patterns. Polysomnography is expensive and difficult to implement, and it is usually used in laboratory studies where these devices and the technical staff are available. A less cumbersome and costly variant is the actigraphy, which is a device that participants wear on the wrist and that measures movement, which enables it to differentiate between probable sleep and wake states (Campbell et al., 2021). Actigraphy is considered to be less precise than polysomnography because it can mischaracterize lying in bed very still as sleeping (Marino et al., 2013), but it is more precise than self-report. Studies have shown that participants tend to overestimate their sleeping time when it is measured by self-report (Tremaine et al., 2010; Lehrer et al., 2022). However, actigraphy is still expensive and logistically difficult to implement, since each participant must get their own wrist device, wear it through the duration of the entire study and return it once the study finishes. It is usually not used in studies where sleep is not the exclusive focus.

To sum up, measuring sleep via daily diaries is the most accurate measurement that can be achieved if not using the polysomnography or actigraphy. Actigraphy is a method that can be

implemented in a diary study (e.g., Campbell et al., 2021), but it requires substantial financial and logistical resources.

### 1.11 How will this study address gaps from previous research

This study will use the framework of the Self Determination Theory (Ryan & Deci, 2017), more specifically Basic Psychological Need Theory (BPNT). Its focus will be put on adolescents, who may be especially prone to the influence of video games on their well-being and sleep. It will seek to answer questions of whether real-life and in-game psychological needs predict gaming time, well-being and sleep and whether gaming time predicts well-being and sleep. Its main contribution, on the theoretical level, will be bringing all of these elements together in one model and simultaneously controlling for the influence of all of them when predicting the criteria. Namely, previous studies would use, for example, just in-game need satisfaction to predict gaming time and well-being, without controlling for the major contribution of real-life need satisfaction, or they would use gaming time to predict well-being and sleep, without controlling for the contribution of in-game need-based experiences. On the methodological level, this study will use the intensive longitudinal design, which is, as already elaborated in previous chapters, the most appropriate for addressing this subject, as it allows the assessment of within-person relationships and the reduction of retrospective bias. Further, the study will examine the effects of need-based experiences and gaming time on well-being in detail, i.e., while dividing well-being into multiple hedonic and eudaimonic constructs. It will include sleep as well, which will make it the first intensive longitudinal study about gaming to include sleep as a criterion.

### 1.12 Aim of this research, problems and hypotheses

The main aim of this research is to examine the relations between basic psychological needs and gaming and between gaming and well-being and sleep.

The problems and hypotheses can be depicted by the following model (see Fig. 1). This model, and its hypotheses that are depicted and later described, all refer to the variables measured at the daily level, i.e., within-person variables. In this model, hypotheses that reflect three problems are specified: (1) Do psychological need satisfaction and frustration in games and in real life predict gaming time and well-being, both directly and indirectly through gaming time?

(2) Do psychological need satisfaction and frustration in games and in real life predict sleep, both directly and indirectly through gaming time? and (3) Does gaming time predict well-being and sleep?

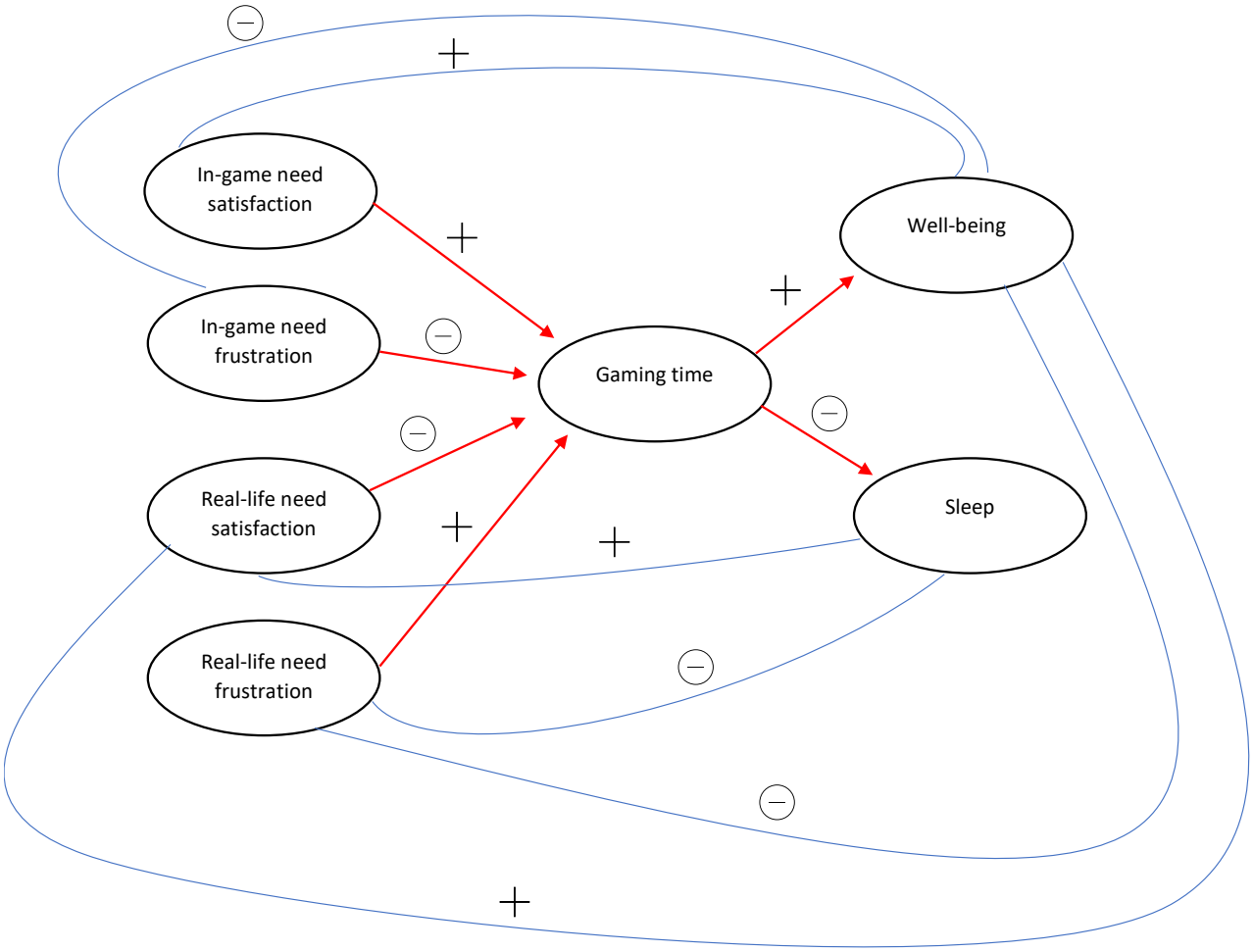


Figure 1. A depiction of the model with hypotheses. "+" means a hypothesized positive relationship and "-" a hypothesized negative relationship.

(1) *Do psychological need satisfaction and frustration in games and in real life predict gaming time and well-being, both directly and indirectly through gaming time?*

According to SDT, (1a) it is expected that in-game need satisfaction will be positively related to gaming time, similar to what Allen (2020) and others in previous studies obtained. (1b) In-game need frustration will be negatively related to gaming time. (1c) Real-life need satisfaction should, according to the need-density hypothesis, be negatively related to playing time, as those with lower real life need satisfaction should play more to compensate it with need satisfaction in-games. (1d) According to the same logic, real life need frustration should be positively

related to video game play, as those who have their needs frustrated in real life might compensate it with playing time.

All the need variables will be related to well-being, indirectly through gaming time, and directly as well. Direct relations between (1e) real life need satisfaction and well-being (positive) and (1f) real life need frustration and well-being (negative) were demonstrated in numerous studies, as this is one of the key propositions of the SDT (Ryan & Deci, 2017). SDT also proposed that engagement in activities that satisfy needs leads to higher well-being even if these activities are virtual, so I will hypothesize about a positive relationship between (1g) in-game need satisfaction and well-being. (1h) In-game need frustration was found to be negatively related to well-being in some studies (e.g., Kosa & Uysal, 2022), whereas in a daily diary study by Allen (2020) it was not related to well-being, likely due to" floor effects". I will hypothesize about a negative relationship since the SDT proposes that experienced need frustration in activities leads to lower well-being.

*(2) Do psychological need satisfaction and frustration in games and in real life predict sleep, both directly and indirectly through gaming time?*

Previous studies provide mixed results about a direct relationship of real-life need satisfaction and frustration and sleep (it was mediated through fatigue in the study by Campbell et al., 2021). I will nevertheless hypothesize about (2a) positive relation between real-life need satisfaction and sleep and (2b) negative relation between real-life need frustration and sleep since this is according to what can be inferred from the SDT. Relations between in-game need satisfaction and sleep and in-game need frustration and sleep were never investigated, but I will hypothesize about (2c) a negative relationship between in-game need frustration and sleep since Przybylski et al. (2014) have shown that in-game need frustration leads to aggression and this could disturb sleep and (2d) I will explore the relationship between in-game need satisfaction and sleep, without a prior hypothesis. Note: these last two hypotheses are not depicted in the model picture, because it would look too visually confusing.

*(3) Does gaming time predict well-being and sleep?*

Finally, I propose that (3a) gaming time will be slightly, but positively related to well-being, according to diary studies that have shown this relationship (Allen, 2020; Quist, 2016). According to previous studies (e.g., Orben & Przybylski, 2020), I propose that (3b) gaming time will be negatively, but weakly, related to sleep.

In addition to testing hypotheses 3a and 3b, I will also examine random slopes for the relationships between gaming time and the criteria and examine whether these relationships are moderated by the most played game genre on a given day and by variables measured at the baseline: gaming disorder symptoms, harmonious and obsessive passion, and self-control. The relationship between gaming time and sleep will be further investigated by examining the relationship between late night gaming and sleep.

The entire model is structured as a mediational model, meaning that the described hypotheses also imply a mediation from psychological needs satisfaction and frustration to well-being and sleep via gaming time. However, according to what can be inferred from previous studies and the relatively small effects of gaming time on well-being and sleep, it is assumed that, generally, direct effects will be stronger than the mediated effect.

# 2. METHOD

## 2.1 General description

This study consisted of two parts: the pilot study and the main study. In the pilot study, the researcher first verified the questionnaire items translations together with adolescent gamers in three focus groups (N=4 in each group). In the second part of the pilot study, recruited gamers (N=7) participated in a study which was the same as the main study, and this was done to assess the feasibility of the main study. In the main study, the recruited adolescent gamers (final N=125) first filled in the informed consent form and the baseline questionnaire including the demographic information and trait surveys via the Expi well app, which was used for data collection. After filling in the baseline questionnaire, the participants were asked to write a short action and contingency plan and on the following day the participants started to fill in the daily questionnaires. For eight consecutive days, each morning they filled in the questionnaire which measured their sleep quantity and quality from the previous night. Each evening they filled in a questionnaire which measured their daily real-life and in-game psychological need satisfaction and frustration, gaming time, positive and negative affect, vitality, physical symptoms, and positive and negative consequences of video games and they answered a question asking whether their day was unusual in any way. At the end of the study, each participant received a 10-euro gift card.

## 2.2 The pilot study

Before the main study, a pilot study was conducted with two aims: a) to assess the feasibility of the main daily diary study and b) to assess the suitability of instrument translations to Croatian and to amend the instrument translations per participants' suggestions if necessary. The pilot study consisted of two parts. In the first part, three focus groups with 4 adolescent gamers in each group (N=12), 9 male and 3 female gamers in total, were held. In each of the focus groups, the gamers first filled in the questionnaires that were going to be used in the main study, and then they discussed the meaning of each item from every questionnaire together with the researcher. They were asked if and how they understood the items. If they did not understand a given item or understood it differently than it was intended, they discussed a possible change in the item's phrasing together with the researcher. Gamers generally understood the items well. They suggested that the item 11 from the short version of the Basic Psychological Need Satisfaction and Frustration Scale (Chen et al., 2014; Mabbe et al., 2018) "I experienced a warm feeling with the people I spend time with" [In Croatian: *"Osjećao sam*

*toplinu kad sam bio s ljudima s kojima inače provodim vrijeme".*] should be rephrased to "I experienced pleasant feelings with the people I spend time with [In Croatian: "*Ugodno sam se osjećao kad sam bio s ljudima s kojima inače provodim vrijeme"*]. They understood this wording better, and they felt that it sounded more natural within the Croatian language. Since the short version of the Basic Psychological Need Satisfaction and Frustration Scale (Chen et al., 2015; Mabbe et al., 2018) was intended to measure in-game and real life need satisfaction and frustration, each with a separate set of duplicate items (see the Instruments section), the researcher decided to add "Today, in my life outside video games…" or "Today, while playing video games…" at the beginning of each item. This was done to make sure that the gamers understood correctly which scale and which item referred to needs within video games and which pertained to needs within real life. Namely, it was observed during focus groups that some adolescent gamers failed to notice a mere description at the beginning of each scale and they would not understand whether the following items referred to needs within real life or needs within video games.

After the focus groups, a small pilot study (N=7) was conducted following the same procedure as the main study to assess its feasibility. The purpose of the pilot study was to assess whether the participants will be able to comply with the study design, i.e., will they fill in the questionnaires two times per day for eight straight days and will the Expi Well app be fully functional. The study was successfully completed by all the participants and the app did not show any major technical issues.

### 2.3 Main study procedure

For the main study, participants were recruited via an article posted by an online gaming magazine (FFA.hr Gaming Portal). A pool of participants from a previously conducted qualitative study (Razum & Huić, 2023) who agreed to take part in future studies were contacted as well, and they contacted their friends to inform them about the study ("snowball sampling"). One participant shared a TikTok video advertising the study. At the end of the study, each participant who completed the study was awarded with a Steam[2] gift card worth 10 euro. Ethical approval was obtained from the author's institution. To take part in the study, participants had to attend high school, be allowed by their parents to play video games, and

[2] Steam is a digital platform that is used for purchasing and playing online and offline games played on a computer. It is the largest digital distribution platform for computer games (Wikipedia, n.d.).

play video games daily. The study took part during spring 2022, when participants had school classes.

After hearing about the study, participants first contacted the researcher via e-mail or the social network Discord[3] and they were given a short description of the study and a link to the Expi Well app on Google play store or App store, which was used for data collection. Participants were informed that they are first going to fill in the consent form and the baseline questionnaire and, starting from the following day, each morning they will fill in the morning questionnaire and each evening they will fill in the evening questionnaire for eight consecutive days, including six weekdays and two weekend[4] days. At the end of the study, they will receive a Steam gift card.

After downloading the Expi Well app, participants were given a code which they used to join the study. They first read the informed consent document, where study's procedures were described in detail, and they were asked to notify their parents about their participation in the study. In accordance with the Croatian Ethical code of research conducted on children (Ajduković & Keresteš, 2020), participants older than 14 but younger than 18 decide by themselves whether they are going to participate in a research study, but they need to notify their parents about their participation.

After they gave consent to participate in the study, participants filled in the baseline questionnaire within the Expi Well app, which included the variables that were measured just once at the beginning of the study.

At the end of the baseline questionnaire, instructions about further study procedures were given to the participants, detailing how they would fill in questionnaires in the morning and in the evening for eight consecutive days, starting from the following morning.

To make sure that they understood the instructions and to facilitate their commitment to the study, the participants were then asked to write a short action and contingency plan. A similar procedure was utilized in the doctoral study by Allen (2020). The text was as follows:

[3] Discord is a digital platform where users can communicate with voice and video calls and instant messaging. It is often used by gamers to communicate while playing video games or outside games. It also allows gamers to participate in different servers, which have channels about video games and related content. The platform allows anonymity, and it is popular among gamers (Wikipedia, n.d.; Statista, 2022).

[4] Participants were asked to start with the study and fill in the baseline questionnaire on any day but Friday or Saturday. In such a way the daily part of the study that started a day after filling in the baseline questionnaire included 6 weekdays and 2 weekend days for every participant.

> We know that this study looks demanding. However, it will become easier after you start, and perhaps you will even like it and learn something about yourself. Before that, it is useful to write a short plan. In this plan, you will state how you will fill in the questionnaires and what will you do if you miss a questionnaire. You will fill in the morning questionnaires in the morning after you wake up, and you should fill in the evening questionnaire before you go to sleep, but also before 23:59 in the evening. Your plan could look like this: "Every day when I wake up in the morning, I will take my phone and fill in the morning questionnaire, and in the evening before I go to sleep and before midnight, I will fill in the evening questionnaire. If I forget to fill in a questionnaire, I will do it as soon as I remember it." Write your plan in the box below. It can be very similar to the plan from this example, but it is very important that you write it in your own words!

After the participants wrote their short action and contingency plans, the study's procedure was shortly repeated to them once more and they were instructed to contact the researcher if they had any issues or needed additional clarifications. Participants were asked to confirm by ticking a box that they understood everything. After that, they received two notifications on their phones every morning at 7:00 and 9:00 for the morning survey and two notifications at 21:00 and 23:00 for the evening survey. They were allowed to fill in the morning survey every day between 7:00 and 16:00 and to fill in the evening survey every day between 21:00 and 23:59. Morning survey was shorter, and participants took 43 seconds on average to complete it, whereas the evening survey was longer, and participants took 5 minutes and 35 seconds on average to complete it. Participants who did not complete the survey after receiving the two notifications on a given day were reminded once more to complete the survey by the researcher who manually sent them an additional notification via the Expi Well app at 14:00 for the morning survey and at 23:30 for the evening survey. After completing the daily part of the study, the participants were instructed to contact the researcher, send a screenshot from the app which showed how many surveys they had completed and served as a proof that they had in fact participated, and the gift card was sent to them digitally.

## 2.4 Participants

A total of 169 participants began the survey by filling in the baseline survey. The data were cleaned and prepared for further analysis by using R version 4.02. (R Core Team, 2020),

including packages “dplyr” (Wickham et al., 2023), “tidyr” (Wickham et al., 2023) and “lubridate” (Grolemund & Wickham, 2011). Firstly, participants who only completed the baseline survey were excluded (n=9), and then the participants who did not complete more than 50% of evening surveys were excluded as well (n=29). This was done as there were 8 evening surveys in total (the morning surveys included just the sleep outcome measure) and it would not be sensible to include participants with just a few data points, especially since most of them essentially stopped participating in the study at a very early point. One participant was excluded because he reported that he was sick from Covid-19 during the study, and 2 participants were excluded because their parents did not allow them to play videogames during the week. Participants who played very little video games during the study were excluded as well (n=4), defined as not playing at all for half or more of the days for which they filled in the questionnaires. These participants also played very little videogames on days when they played video games (e.g., less than two hours of total playing time) and therefore, they were not considered to be playing video games daily, i.e., to be “regular” gamers. Participants’ responses were also filtered by response speed. However, although the response speed increased as participants completed more daily surveys, no participants responded as fast as or faster than 1 second per item in any of the daily surveys, which was shown to decrease the results quality (Wood et al., 2017).

At the end, the final sample consisted of 125 participants. The average completion rate was 88% of completed daily surveys for the evening questionnaire, ranging between 62.5% and 100% for different participants, and 92% of completed daily surveys for the morning questionnaire, ranging between 50% and 100% for different participants. There were no missing data at the level of submitted daily surveys, i.e., the participants filled in all the items in every submitted daily survey, as items in the daily surveys could not be skipped. However, the participants could have stopped participating in the study at any point.

### 2.5 Participant characteristics

Most participants were boys (92%), followed by girls (4%) and those who did not want to disclose their gender (4%). Their age was from 15 to 20 years, and on average they were 17.28 years old (*SD*=1.18 years). Their average grade in the last year of high school was 4.04 on a scale from 1 to 5, which is used in Croatia (*SD*=.54, range = 2.8 – 5.0). Participants were heterogenous according to high school types they were enrolled into: vocational high schools, general gymnasiums, gymnasiums of natural sciences and mathematics, language or classical

gymnasiums (Table 1 in Appendix A). They were also heterogenous according to the size of the locality in which they were living (big city, smaller city, village), county within Croatia, family income, mother's and father's attained level of education and their own religiosity (Table 1 in Appendix A).

The majority of participants considered themselves to be "gamers" (83.2%), others did not (9.6%) or were not sure (7.2%). Most participants primarily played video games on a personal computer (80%), followed by those who primarily played on a console (16.8%) and those who primarily played on a smartphone (3.2%). Most participants were the only users of the device on which they primarily played video games (69.6%), some shared this device with siblings (24%), and a small percentage of them shared it with parents (3.2%) or with both siblings and parents (3.2%). Parents did not limit the gaming time of most participants in any way (84.8%), and others were limited to 2 to 5 hours of gaming per day, or they could play until 10 pm at latest during weekdays. Besides playing video games, participants engaged in other hobbies and free time activities such as: watching movies and series, doing sports, socializing, playing musical instruments, drawing or 3D modelling and learning languages. Only two participants out of 125 selected "often" or "very often" on all four questions of the Gaming Disorder Test (Pontes et al., 2019; described in the Instruments section) and could be classified as problematic gamers.

## 2.6 Instruments

In the following section, the instruments used in the study will be presented: first those administered only once at baseline, that will be used for sample description and additional moderator variables testing, followed by the "core" daily instruments, which will be used to answer the main research questions and test the hypotheses. All instruments for which there were no Croatian translations available were first translated by two independent translators by using the translation-back-translation method (Gudmundsson, 2009). Afterwards, the translated instruments were, as described in "The pilot study" section, presented to adolescent gamers, who discussed their understanding of items with the researcher and suggested amendments if necessary.

### 2.6.1 Baseline questionnaire - items and constructs measured only at baseline

#### 2.6.1.1 Demographic variables

Participants reported their gender, age, name of the high school they are attending and the high school year they are currently in. They also reported with whom they currently live, in how big

of a locality (e.g., village, city) and in which municipality they live, and where do they live during the school week. They reported the highest educational degree achieved by their parents, the general estimation of their family income and how is their family living with this income, their religiosity, and their GPA at the end of the last school year. They reported whether they consider themselves to be "gamers", on which device do they most play videogames, whether they share this device with other household members, whether their parents or caregivers limit their videogame playing time, and in which other activities besides gaming they take part in their free time.

#### 2.6.1.2 Gaming Disorder

Gaming Disorder was measured with the Gaming Disorder Test (Pontes et al., 2019), which uses the ICD-11 conceptualization of this condition. The questionnaire has four items (e.g., *I have had difficulties controlling my gaming activity.*), each measuring whether the participants experienced a given Gaming Disorder symptom during the last year. In accordance with the insights obtained in a previously conducted qualitative study (Razum & Huić, 2023) and in another study as well (Schmidt et al., 2022) "During last year…" was added at the beginning of every item for the participants to be aware that the items refer to their experiences during last year. Items were answered on a 5-point scale, from 1-never to 5-very often. To reach the threshold for problematic gaming, a participant had to endorse every item with "often" or "very often" (Pontes et al., 2019). Omega reliability for this scale was ω=.81.

#### 2.6.1.3 Passion for gaming

Passion for gaming was measured with the Passion scale (Vallerand, 2010, Vallerand et al., 2003). The questionnaire has 12 items, with 6 items measuring Harmonious passion (e.g., *Gaming is well integrated in my life*.) and 6 items measuring Obsessive passion (e.g., *I have the impression that gaming controls me.*). The items are answered on a 7-point scale from 1 - Do not agree at all to 7 - Very strongly agree. Omega reliability for the Obsessive passion subscale was ω=.78 and for the Harmonious passion subscale it was ω=.84.

#### 2.6.1.4 Self-control

Self-control was measured with the Self-Control Scale (Tangney et al., 2004). The questionnaire has 13 items (e.g., *I wish I had more self-discipline*), which are answered on a 5-point scale, from 1- Not at all to 5- Very much. Omega reliability for the Self-Control Scale was ω=.64.

### 2.6.2 Daily questionnaires - Evening surveys

#### 2.6.2.1 Basic psychological in-game and real-life need satisfaction and frustration

Daily basic psychological in-game and real-life need satisfaction and frustration were measured with the 12-item version of the Basic Psychological Need Satisfaction and Frustration Scale (Chen et al., 2015; Mabbe et al., 2018). The participants filled in the scale two times, once for the satisfaction and frustration of needs in real life outside video games and once for satisfaction and frustration of needs in video games. As already mentioned, each item started with either "Today, in my life outside video games…" or "Today, while playing video games…". In both the real-life and in-game versions, the scale measured the satisfaction (e.g., *I felt a sense of choice and freedom in the things I did.*) and frustration (e.g., *I felt disappointed with many of my performance.*) of autonomy, competence and relatedness, and each need was measured with two items. In case of in-game need satisfaction and frustration, on the days when participants did not play videogames, they were assigned missing values within that variable. As it will be presented in detail in the Confirmatory factor analyses section, at the within person level, two models were specified, one with two factors measuring in-game and real life need satisfaction, and another with two factors measuring in-game and real life need frustration. Both models fitted the data well, and the within person reliabilities were as follows: ω=.47 (real life need satisfaction), ω=.52 (in game need frustration), ω=.61 (real life need frustration), and ω=.61 (in-game need frustration).

#### 2.6.2.2 Gaming time

Daily gaming time was measured with the questions from the General Media Habits questionnaire (Gentile et al., 2004), which were also used in the daily diary study by Allen (2020). Participants reported how many hours and minutes (e.g., two hours and ten minutes) they played videogames during each of the four blocks of time: (previous) Midnight to 6 am, 6 am to Noon, Noon to 6 pm, 6 pm to Midnight. The times were added up to compute the measure of total gaming time on that day. If participants did not plan to go to sleep immediately after filling out the evening questionnaire, but they planned to play more videogames before midnight, they were instructed to take this into account when estimating their gaming time from 6 pm to Midnight.

Mean daily gaming time for the participants was 4 hours and 7 minutes (SD= 2 hours and 52 minutes). Mean daily gaming time during weekends was 5 hours and 5 minutes (SD = 2 hours and 53 minutes) and during weekdays 3 hours and 49 minutes (SD = 1 hour and 50 minutes).

#### 2.6.2.3 Most played game – game genres

Participants were asked which game they played the most on that day. These games were later recoded into game genres, by using the data from Wikipedia.com (n.d.), and considering genre classifications from previous studies (e.g., Entwistle et al., 2020; Na et al., 2017). Genres that were played very rarely (e.g., only by one or two participants or only on a few occasions) were dropped and in the end six genres were kept: Shooters (e.g., *Counter Strike: Global offensive*), Massive Online Battleground Arena (MOBA) games (e.g., *League of Legends*), Sports games (e.g., *FIFA*), Action and adventure games (e.g., *Grand Theft Auto 5*), Battle Royale games (e.g., *Apex Legends*) and Sandbox games (e.g., *Minecraft*). As they were the most common genre, Shooters were used as the reference genre for the moderation analysis. This means that any moderation effect of a specific genre would be interpreted as a moderation effect of playing a game belonging to that genre versus playing a shooter game. Genres were distributed as follows, with the percentage of times a given genre was the dominant genre on a given measurement occasion presented in the brackets: Shooters (46.2%), MOBA (20.9%), Action and adventure (9.6%), Sports (9.1%), Battle Royale (8%), and Sandbox (6.2%).

#### 2.6.2.4 Positive and negative affect

Daily positive and negative affect was measured with a scale from Diener and Emmons (1984). Four items measured the positive affect (e.g., *Happy*) and five items measured the negative affect (e.g., *Frustrated*). The items were answered on a 7-point scale, from 1- Not at all to 7 – Extremely. As it will be presented in the Confirmatory factor analyses section, the two-factor model fitted the data well at the within person level and the reliabilities were ω=.76 for the positive affect subscale and ω=.82 for the negative affect subscale.

#### 2.6.2.5 Vitality

Daily vitality was measured with the Subjective Vitality Scale from Ryan and Frederick (1997), which was shortened to three items while considering item content and factor loadings obtained in previous studies (e.g., Castillo et al., 2017). Items were answered on a 7-point scale, from 1- Not true at all to 7 – Very true. The confirmatory model with one factor for vitality fit the data well at the within person level and the within person scale reliability was ω=.74.

#### 2.6.2.6 Physical symptoms

Daily physical symptoms were measured with the short 3-item scale used in a study by Espinoza et al. (2013), from which the sleep item was additionally removed since sleep is

already measured in this study. After conducting the confirmatory factor analysis at the within person level, another item was removed and only one item was left in the scale referring to headaches experienced by participants on that day. The item was rated on a 7-point scale from 1- Not at all to 7-almost all the time.

#### 2.6.2.7 Positive and negative effects of video games

Daily positive and negative effects of video games were measured with two items constructed for the purposes of this study, which were based on a previously conducted qualitive study (Razum & Huić, 2023). Positive consequences of video games were measured with the item: *I believe that playing videogames today brought me good things. For example, I learned something new, I hung out with others.* Negative consequences of video games were measured with the item: *I believe that playing videogames today brought me bad things. For example, because I played videogames, I did not have time for another important activity that I wanted to do today, like studying or doing schoolwork, going out with friends, doing a hobby, doing sports.* Both items were answered on 7-point scale, from 1- completely disagree to 7- completely agree. Mean of daily positive consequences of video games was 4.17 (SD=1.79), and mean of daily negative consequences of video games was 2.93 (SD=1.71). Their intraclass correlations were .46 and .38, respectively, which indicates substantial and sufficient within person variation (Gabriel et al., 2018).

#### 2.6.2.8 Unusual day

All participants answered whether that day was unusual in any way and, if yes, why.

### 2.6.3 Daily questionnaires - Morning surveys

#### 2.6.3.1 Sleep quality

Daily (subjective) sleep quality was measured with a visual analogue scale (VAS) adapted from Pittsburgh sleep diary (Monk et al., 1994; used in study by Campbell et al., 2021). Participants rated a VAS that measured their previous night's subjective sleep quality ("How was your sleep quality last night?") on a scale from 0 (extremely poor) to 10 (extremely good). Mean daily sleep quality for the participants was 8.78 (SD=2.42). Intraclass correlation of daily sleep quality was .33, which indicates substantial and sufficient variation for analyses at the within person level (Gabriel et al., 2018).

#### 2.6.3.2 Sleep quantity

Daily sleep quantity was calculated from four questions, according to what was done in the study by Campbell et al. (2021), who used the questions from Monk et al. (1994). The questions assessed evening bedtime, morning wake-time, number of minutes the participants took to fall asleep (sleep latency), and the number of minutes spent awake after the initial sleep started (wake after sleep onset). Total time in bed was first computed by subtracting morning wake-time from the evening bedtime and then the daily sleep duration i.e., sleep quantity, was computed by subtracting sleep latency and wake after sleep onset from the total time in bed. Mean daily sleep quantity for the participants was 7 hours and 40 minutes (SD= 1 hour and 49 minutes). Intraclass correlation of daily sleep quantity was .21, which indicates substantial and sufficient variation for analyses at the within person level (Gabriel et al., 2018).

# 3. RESULTS

## 3.1 General analysis strategy and remarks

The main analytical method used was multilevel structural equation modelling (MSEM; Hallquist, 2017; Sadikaj et al., 2021), which brings several advantages over the traditional multilevel regression procedures. Firstly, MSEM allows to test the measurement model. It does not unrealistically assume that predictors are measured without error nor that measures are perfectly reliable and that the composite measures can be formed by creating simple sum scores (Sadikaj et al., 2021). Not taking the measurement unreliability into account can lead to seriously erroneous conclusions about the incremental contribution of predictors (Westfall & Yarkoni, 2016). Also, when we create composite measures by summing up the scale items, we actually assume a very strict model where unstandardized factor loadings and error variances of all items are equal – and this is often not a realistic assumption (McNeish & Gordon Wolf, 2020). Moreover, the factor structure of scales needs to be verified, even when those scales were already validated, and this is rarely done in studies (Flake et al., 2017). This is especially important in the context of intensive longitudinal or daily diary studies, as the items and scales do not necessarily behave the same at the within person level of analysis (Gabriel et al., 2018) as they do in cross sectional research where they were developed. However, multilevel confirmatory factor analyses are rarely conducted (Gabriel et al., 2018). Secondly, MSEM allows to use multiple criteria simultaneously and to test mediational models, a possibility that the multilevel regression procedures do not provide. By using the latent decomposition of variance, it also allows to partition the between person and within person variance without bias (Sadikaj et al., 2021).

In this analysis the focus was put on the within person relationships, which can be investigated with diary studies. Namely, as mentioned in the introduction, in a cross-sectional study and other studies that are not truly longitudinal the obtained result is actually a mixture of the between person stable differences and within person processes (Hamaker, 2012), although it is assumed that it mostly captures the between person variance, because questionnaires are designed to measure stable traits. Diary studies allow the between person and within person variance to be separated (Bolger & Laurenceau, 2013). Between person relationships relate to whether one disposition predicts another. A significant between-person relationship means that people who have higher scores on a predictor trait also have higher scores on the criterion trait. Within person relationships relate to whether fluctuations in one trait predict or co-occur with fluctuations in another trait (Sadikaj et al., 2021). A significant within person relationship

means that when a person scores above their daily average on a predictor this predicts or co-occurs with an increase in the criterion. In a hypothetical example, on the between person level, those who play more video games would also on average experience a slightly higher well-being, and on the within level, those who played more video games than their daily average on a given day, would experience higher well-being on that day. Studying within person relationships allows us to study processes as they unfold on a daily level, and it brings methodological advantages because this reduces the retrospective bias and allows to use the person as their own control and to remove between subject influences on the relationship between the predictor and the criterion (Bolger & Laurenceau, 2013). It does need to be noted that other limitations to inferring causality are still present (e.g., the within person confounding variables), and this will be further elaborated in the Discussion section.

In the following analyses, multilevel confirmatory factor analyses were first conducted to verify the factor structure of used scales and provide evidence for construct validity (Flake et al., 2017). Afterward, structural models that test the hypotheses were tested. All analyses were conducted by using the statistical software Mplus Version 8.8. (Muthén & Muthén, 2022).

### 3.2 Verifying the factor structure of used scales: Multilevel confirmatory factor analyses

As a first step in the analysis, multilevel confirmatory factor analyses were conducted to verify the factor structure of scales used in the study. In this analysis, both the within and between factor structure were examined. A factor analysis on the within level follows the same logic as the within person relationships in general and factor loadings refer to whether changes in the latent variable co-occur with changes in the items within the same day. This is different than the between person level, where higher average scores in the latent variable would be expected to correspond to higher average scores in the indicators. All models in the following section were estimated with the MLR estimator, which is robust to deviations from normality. Model fit was assessed with fit indices, while following the guidelines which were derived from simulation studies and are commonly used in applied research (Brown, 2015). Specifically, the values of RMSEA below .08 indicate acceptable fit and values below .05 indicate good fit, the values of CFI and TLI between .90 and .95 indicate acceptable fit and values above .95 indicate good fit and the values of SRMR below .08 indicate good fit. The $\chi^2$ test results were reported,

but not interpreted, as this test is overly sensitive in detecting even the most minor sources of model misfit, especially with larger sample sizes (Brown, 2015).

### 3.2.1 Basic Psychological Need Satisfaction and Frustration Scale

The factor structure of the video game and real-life versions of the 12-item Basic Psychological Need Satisfaction and Frustration Scale (Chen et al., 2014; Mabbe et al., 2018) was examined first. Specifically, factor structure of real-life and in-game psychological need satisfaction subscales was first analysed, followed by the factor structure of the real-life and in-game psychological need frustration subscales.

### 3.2.2 Real-life and in-game need satisfaction subscales

Descriptive statistics (means, standard deviations and intraclass correlations) and standardized within person factor loadings of variables included in the real life and in-game psychological need satisfaction subscales are presented in Table 1. Items are presented as ordered in the scale. Real life need satisfaction items are presented as parcels because the model with the parcelized subscale items (three parcels for six items) was selected as the final model.

Table 1 Means, standard deviations, intraclass correlations and standardized within person factor loadings for real life and in-game psychological need satisfaction

| Item (Need satisfaction) | Mean | SD | Intraclass correlation (ICC) | Standardized within person factor loading |
|---|---|---|---|---|
| Real life 1 | 3.92 | .81 | .52 | .50 |
| Real life 2 | 3.88 | .92 | .54 | .38 |
| Real life 3 | 3.78 | .90 | .48 | .54 |
| | | | | |
| In-game 1 | 4.16 | .95 | .39 | .29 |
| In-game 2 | 3.78 | 1.08 | .37 | .43 |
| In-game 3 | 3.84 | 1.01 | .37 | .35 |
| In-game 4 | 3.85 | 1.07 | .37 | .38 |
| In-game 5 | 3.85 | 1.03 | .38 | .39 |
| In-game 6 | 3.91 | 1.10 | .34 | .46 |

*Note:* All standardized factor loadings are significant at $p<.001$.

We can observe that the intraclass correlations, which denote the percentage of variance that can be attributed to between person factors, are of sufficient value to indicate more than substantial variation at the within person level (Gabriel et al., 2018). Namely, the percentage of within person variation equals to 1 minus the value of the intraclass correlation. This indicates that it is sensible to analyse the data at this level and intraclass correlations pointing to high percentages of within person variance can be observed in other items in this study as well, which are presented in the following tables (Table 2 – Table 4).

Confirmatory models of real-life and in-game psychological need satisfaction and real-life and in-game need frustration subscales were tested, and the fit was considered separately at the within and the between levels. Fit at different levels was computed by specifying the investigated model at the level of interest and specifying the fully saturated model with zero degrees of freedom (i.e., all manifest variables correlated with each other) at the other level (Sadikaj et al., 2021). For example, if one would want to examine the model fit at the within level, the model of interest would be specified at the within level, and all manifest variables would be correlated at the between level. The model fit indices would then solely reflect the fit at the within level.

In the first model, the factors of in-game needs satisfaction and in-life needs satisfaction were specified both at the within and the between levels.

At the within level, model fit the data well ($\chi^2(53) = 96.80$, $p<.001$; RMSEA=.031, CFI=.973, TLI=.933, SRMR=.038, BIC[5]=25787.6). The reliability for real-life needs satisfaction subscale was ω=.47 and for the in-game need satisfaction subscale ω = .52. In an attempt to improve model fit and reliability, the real-life need satisfaction subscale was parcelized by combining the items that measured autonomy, competence, and relatedness into one item per need. Each need was now measured by one item which was computed as the mean of the sum of the two original items. The resulting within level model provided better fit to the data ($\chi^2(26) = 39.36$, p=.045, RMSEA=.024, CFI=.989, TLI=.969, SRMR=.032, BIC=17534.9). This can be concluded because of the chi square value which is now almost non-significant and because of better relative fit indices values (e.g., TLI), but also because of a smaller BIC value (25787.6 in the previous model versus 17534.9 in this model). However, the reliability of the real-life need satisfaction scale was the same, ω=.47. The correlation between real life and in-game

[5] The BIC index was used in this case to compare the models with and without parcelized real-life satisfaction subscale because two non-nested models can only be compared through such indicators (Brown, 2015). In the following chapters, models were not compared and therefore BIC was not used anymore.

need satisfaction factors was .49 (p<.001). Standardized within person factor loadings for real-life and in-game need satisfaction subscale items are presented in Table 1.

At the between level, the two-factor model of real-life and in-game need satisfaction was first tested, because it was expected that real-life and in-game need satisfaction would form two separate factors. The initial two-factor model did not fit the data well ($\chi^2(53) = 286.67$, p<.001, RMSEA=.071, CFI=.857, TLI=.644, SRMR=.060). After including an error covariance between the first item from the in-life needs satisfaction subscale and the first item from the in-game needs satisfaction subscale, both items measuring autonomy, the fit became somewhat acceptable, apart from the TLI indicator, which had a lower than acceptable value ($\chi^2(52) = 213.91$, p<.001, RMSEA=.059 CFI=.901 TLI=.749, SRMR=.049). Further error covariances suggested by the modification indices could not be added because the model would produce a non-positive definite residual matrix, and the reason could be a combination of the high multicollinearity between the variables and a smaller sample size at the between level (Brown, 2015). Due to the high communalities and a smaller sample size, the residual variance(s) could be pushed toward negative values because of the sampling error. The omega reliabilities for needs satisfaction subscales were extremely high, namely ω=.98 for both real-life needs and in-game need satisfaction scales. The two factors also had an extremely high factor correlation (r=.98), and therefore a one factor model, with only one factor encompassing both life needs and gaming needs satisfaction was fitted as well, although it is not of theoretical interest. This model did not fit the data well initially ($\chi^2(52) = 281.43$, p<.001, RMSEA=.069, CFI=.861, TLI=.660, SRMR=.061). When the two error covariances between the first items and the sixth items from the life needs satisfaction subscale and the gaming needs satisfaction subscale were added (two items from each scale measuring autonomy), the fit became somewhat acceptable ($\chi^2(52) = 185.63$, p<.001, RMSEA=.054, CFI=.918, TLI=.792, SRMR=.049), apart from the TLI indicator, which was lower than acceptable. Neither the two-factor nor the one-factor models at the between level produced completely acceptable solutions.

### 3.2.3 Real-life and in-game need frustration subscales

In the following model, the real-life and in-game psychological need frustration subscales were analysed, and the factors of in-game and real-life need frustration were specified both at the within and the between levels. Descriptive statistics (means, standard deviations and intraclass

correlations) of variables included in the real life and in-game psychological need frustration subscales are presented in Table 2.

Table 2 Means, standard deviations, intraclass correlations and standardized within person factor loadings for real-life and in-game psychological need frustration

| Item (Need frustration) | Mean | SD | Intraclass correlation (ICC) | Standardized within person factor loading |
|---|---|---|---|---|
| Real life 1 | 2.65 | 1.33 | .48 | .40 |
| Real life 2 | 2.41 | 1.29 | .51 | .60 |
| Real life 3 | 2.80 | 1.23 | .44 | .35 |
| Real life 4 | 2.42 | 1.34 | .54 | .50 |
| Real life 5 | 2.74 | 1.24 | .44 | .42 |
| Real life 6 | 2.57 | 1.24 | .47 | .45 |
| | | | | |
| In-game 1 | 2.68 | 1.29 | .54 | .41 |
| In-game 2 | 2.40 | 1.32 | .58 | .50 |
| In-game 3 | 2.57 | 1.29 | .51 | .45 |
| In-game 4 | 2.42 | 1.36 | .59 | .48 |
| In-game 5 | 2.52 | 1.28 | .52 | .42 |
| In-game 6 | 2.63 | 1.33 | .44 | .43 |

*Note:* All standardized factor loadings are significant at p<.001.

At the within level, the model provided good fit according to the conventional benchmarks ($\chi^2(53) = 89.18$, p<.001; RMSEA=.028, CFI=.983, TLI=.957, SRMR=.038). The reliability for real-life need frustration subscale was ω=.61 and for the in-game need frustration subscale ω = .60. The correlation between real life and in-game need frustration factors was .70 (p<.001). Standardized within person factor loadings for real-life and in-game need frustration subscale items are presented in Table 2.

At the between level, the two-factor model provided an acceptable fit across all indicators but the TLI ($\chi^2(53) = 221.21$, p<.001, RMSEA=.060 CFI=.920 TLI=.801, SRMR=.040). The omega reliabilities were extremely high, namely ω=.98 for life needs frustration and ω=.98 for gaming needs frustration. Since the two factors had an extremely high factor correlation (r=.99), one factor model was tested as well. This model again provided an acceptable fit

according to all indicators but the TLI ($\chi^2(54) = 217.48$, p<.001, RMSEA=.059 CFI=.923 TLI=.811, SRMR=.040). As was the case with psychological need satisfaction, neither the two-factor not the one-factor models at the between level produced completely acceptable solutions.

As mentioned, this is probably due to the high multicollinearity at the between level and the degree of model complexity (Brown, 2015), coupled with the relatively small sample size at this level, since for it the effective sample size was equal to the number of participants (n=125), and not to the number of participants times the number of measurement occasions as it is for the within level. Due to the high communalities and the small sample size, the residual variance(s) could also be pushed toward negative values because of the sampling error.

### 3.2.4 Positive and negative affect scales

The factor structure of positive and negative affect (Diener & Emmons, 1984) was examined next. The descriptive statistics of the items included in the scales (means, standard deviations and intraclass correlations (ICC) are presented in Table 4.

Table 3 Means, standard deviations, intraclass correlations and standardized within person factor loadings for positive and negative affect (Diener & Emmons, 1984)

| Item | Mean | SD | Intraclass correlation (ICC) | Standardized within person factor loading |
|---|---|---|---|---|
| *Positive affect* | | | | |
| Happy | 5.59 | 1.30 | .46 | .66 |
| Joyful | 5.66 | 1.34 | .47 | .79 |
| Pleased | 5.55 | 1.38 | .35 | .68 |
| Enjoyment/fun | 5.38 | 1.62 | .35 | .56 |
| *Negative affect* | | | | |
| Depressed/blue | 2.49 | 1.79 | .29 | .48 |
| Unhappy | 2.27 | 1.59 | .32 | .74 |
| Frustrated | 2.46 | 1.60 | .32 | .82 |
| Angry/hostile | 2.13 | 1.50 | .34 | .79 |
| Worried/anxious | 2.40 | 1.61 | .33 | .64 |

*Note:* All standardized factor loadings are significant at p<.001.

At the within level, the initial model provided acceptable fit ($\chi^2(26) = 118.28$, $p<.001$, RMSEA=.063, CFI=.961 TLI=.891, SRMR=.040), apart from the TLI indicator that was slightly lower than the benchmark values. The model was modified to include a covariance between the errors of items one and two of the negative affect subscale, which measured being "depressed/blue" and "unhappy". The modified model provided good fit ($\chi^2(25) = 47.52$, $p=.004$, RMSEA=.032, CFI=.990 TLI=.972, SRMR=.031). The omega reliabilities were $\omega=.76$ for the positive affect subscale and $\omega=.82$ for the negative affect subscale. The correlation between the positive and negative affect factors was -.42 ($p<.001$). Standardized within person factor loadings for positive and negative affect subscale items are presented in Table 3.

At the between level, the two-factor model provided good fit ($\chi^2(26) = 74.43$, $p<.001$, RMSEA=.046, CFI=.979 TLI=.943, SRMR=.061), but produced a non-positive definite residual covariance matrix, due to a slightly negative residual variance of the first item on the positive affect scale. Because of this, the results cannot be interpreted with confidence. The reasons behind an inadmissible solution in this case are probably the same as the ones described with the psychological needs scales. The correlation between the factors was not high (-.41, $p<.001$), and the alternative one factor model, with the positive and the negative affect items both loading on the same factor, did not provide an acceptable fit ($\chi^2(27) = 268.12$, $p<.001$, RMSEA=.101, CFI=.898, TLI=.727, SRMR=.312), while also producing a non-positive definite residual covariance matrix.

### 3.2.5 Vitality and physical symptoms scales

Finally, the factor structures of the vitality scale (Ryan & Frederick, 1997) and physical symptoms (Espinoza et al., 2013) were examined. Since these two scales have only three and two items respectively, they were examined in the same model to be able to identify models, obtain an overidentified solution and examine model fit (Brown, 2015). The descriptive statistics of scale items (means, standard deviations, and ICC's) are available in Table 4.

Table 4 Means, standard deviations, intraclass correlations and standardized within person factor loadings for the Vitality scale (Ryan & Frederick, 1997) and the physical symptoms item (Espinoza et al., 2013)

| Item | Mean | SD | Intraclass correlation (ICC) | Standardized within person factor loading |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Vitality 1 | 4.96 | 1.64 | .48 | .57 |
| Vitality 2 | 4.96 | 1.58 | .43 | .86 |
| Vitality 3 | 4.99 | 1.64 | .39 | .65 |
| Physical symptoms 2 | 2.24 | 1.70 | .42 | - |

*Note:* All standardized factor loadings are significant at p<.001.

The initial model with a factor for vitality and another factor for physical symptoms provided good fit at the within person level according to the benchmarks ($\chi^2(4) = 10.97$, p=.027, RMSEA=.044, CFI=.991 TLI=.954, SRMR=.023), but the residual covariance matrix was not positive definite because item 2 of the physical symptoms scale had a standardized loading larger than one and a negative residual variance. The negative residual variance may be a sign that these two items do not fit on the same construct. It was decided to remove item one ("Back pain, joint pain, or muscle pain") from this scale, since item 2 ("headaches") has more relevant content to the daily experiences of gamers, which was observed in the pilot study. A subsequent model was tested where the latent variable vitality was defined by three manifest variables and physical symptoms was modelled as a manifest variable correlated with the latent variable vitality. The resulting model did not have problems with model identification, and it obtained nearly perfect fit ($\chi^2(53) = .589$, p=.744; RMSEA=.000, CFI=1.00, TLI=1.00, SRMR=.01). The reliability of the vitality construct was good despite the small number of items, with ω=.74. The correlation between the vitality scale and physical symptoms item was -.17 (p<.001). Standardized within person factor loadings for vitality scale items are presented in Table 4.

At the between level, the initial model with the separate factors for vitality and physical symptoms showed good fit ($\chi^2(53) = 5.02$, p=.286; RMSEA=.017, CFI=.999, TLI=.993, SRMR=.024). The reliabilities of the vitality and physical symptoms at the between level were very high, ω=.96 for both constructs.

To summarize, at the within level, models with real-life and in-game need satisfaction scales provided good fit, same as the models with real-life and in-game need frustration scales. Real-life and in-game satisfaction scales had somewhat lower reliability than it is usually defined as good by benchmarks proposed by some authors (e.g., larger than 0.6; Shrout, 1998). However, Nezlek (2017) suggests that these benchmarks should be relaxed in the case of within person studies, as they were developed for use with measures containing many items and measuring

stable traits. Additionally, latent variable modelling does account for measurement unreliability (Sadikaj, 2021), although it is of course desirable to have higher reliability because this increases the amount of "true score" variance that is subsequently used in the analysis. The model with positive and negative affect showed good fit as well when the errors of the first and second item of the negative affect scale were correlated. The vitality scale and physical symptoms scales initially produced an inadmissible solution, but after one item was removed from the physical symptoms scale, the fit was near perfect.

At the between level, the models with need satisfaction and frustration and positive and negative affect encountered problems with the lack of fit and/or provided inadmissible solutions. As already discussed, this is probably because the sample size is limited at this level, variables correlate highly with each other, and it is therefore possible that the parameters obtain out-of-range values due to sampling error. Due to the already discussed theoretical interest in within person effects and these issues, structural models will be examined at the within person level only.

## 3.3 Answering the research questions - structural hypotheses testing

### 3.3.1 General analytical strategy

After the factor structures have been examined, in the following section hypotheses that operationalize the research questions were tested.

When building each of the models, a strategy similar to the two-step procedure described in Kline (2015) was used. Specifically, the fit of the measurement model with all the constructs was tested first to examine sources of a possible misfit and then the fit of the entire model with structural paths that test the hypotheses was examined. As in the previous analyses, the robust MLR estimator was used to account for possible non-normality in the variable distributions. Elapsed time from the beginning of the study, defined as the number of measurement occurrences of a given variable from the beginning of the daily part of the study, was used as a control variable. This was done to control for possible changes in the constructs due to processes such as participant reactivity, where the mere collection of data would change the participant experience. This could cause, for example, a linear increase in the positive affect during the study or a simultaneous increase in two constructs of interest, thus creating spurious relationships. Whether a particular study day was a weekday or a weekend day was entered as

a control variable to control for possible confounding effects of the weekend, when participants could both play more videogames and experience higher well-being. In these multilevel models, the default option in the Mplus software is to include the random intercept, and this was included in all the models.

### 3.3.2 Research questions and hypotheses

#### 3.3.2.1 First research question – psychological needs, gaming time and well-being

1. Do psychological need satisfaction and frustration in games and in real life predict gaming time and well-being, both directly and indirectly through gaming time?

To answer this research question, six models were built to reduce the number of parameters and facilitate model convergence and model interpretation. Three models included need satisfaction in real life and in video games as predictors and the other three models included need frustration in real life and video games. On the criterion side, two models included well-being operationalized through the positive and negative affect, in two models well-being was operationalized through vitality and physical symptoms and in the final two models well-being was assessed through positive and negative consequences of video games. All six models included gaming time as the mediator and time and weekend as the control variables, and all latent variables in the model and gaming time were regressed on them. A covariance was included between the need satisfaction and between need frustration variables in all models, since they were regressed on the control variables and their covariance was then not included by default in Mplus as they were not exogenous variables anymore. Besides the covariance between the need satisfaction or need frustration variables that was specified, a covariance was included by default between the well-being criterion variables in each of the models.

Model 1.1 – real-life and in-game need satisfaction predicting positive and negative affect

The first model included psychological need satisfaction in real life and in video games as the predictors, gaming time as the mediator and positive and the negative affect as the criteria. It also included the indirect relationships between the psychological need satisfaction and the positive and negative affect, as well as the covariates “time” and “weekend”. (Figure 2)

The measurement model, which was tested first, included just the used latent variables, control variables and gaming time, and no predictive relationships, but only covariances among the variables. This model provided a good fit ($\chi^2(170) = 279.92$ $p<.001$; RMSEA=.026, CFI=.977, TLI=.948, SRMR=.036). Mplus issued a warning about a non-positive definite first-order

derivative product matrix; however, it was followed by a message that the warning was likely issued due to having more parameters than clusters. In such a case this warning always appears regardless of the actual problems with model non-identification (Asparouhov & Muthen, 2022). I, therefore, in this and all the following models, assumed that this does not point out to actual problems with identification and continued with the analyses. The structural model, i.e., the model which includes the predictive relationships that answer the research question and test the hypotheses, was fitted next. The structural model achieved a good fit ($\chi 2(170) = 278.18$, $p<.001$; RMSEA=.027, CFI=.977, TLI=.948, SRMR=.036).

The Figure 2. below provides a depiction of the model with the significant path coefficients.

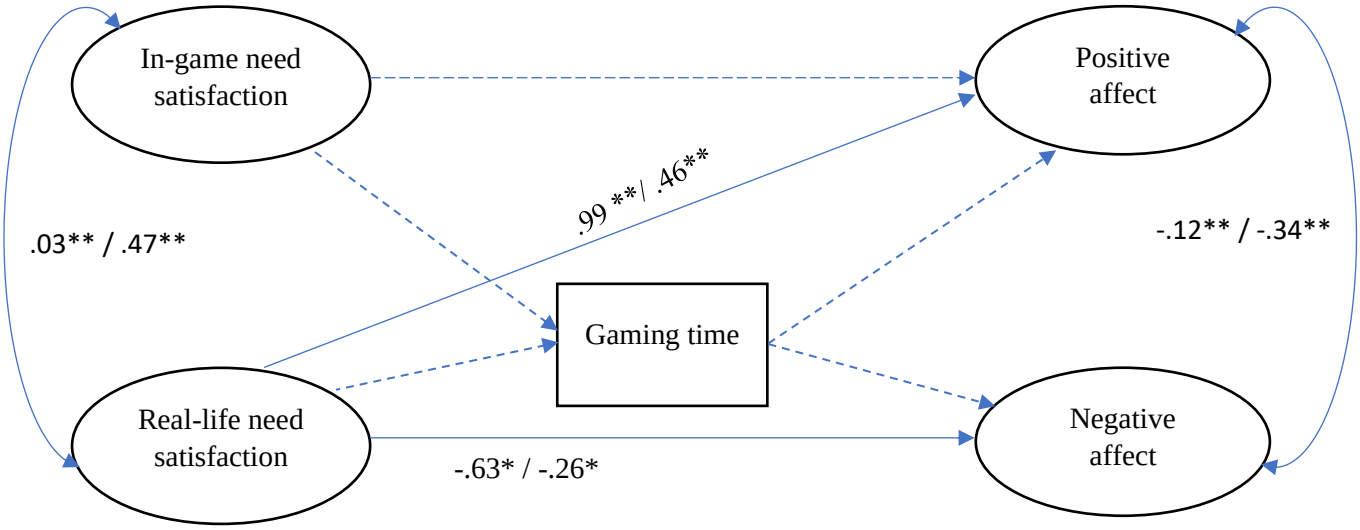


Figure 2. Model 1a. In-game and real life need satisfaction predicting positive and negative affect directly and via gaming time.

*Note*. Values before the dashed lines represent unstandardized coefficients and values after the dashed lines represent standardized coefficients. Broken lines denote unsignificant paths. Paths from covariates "weekend" and "time" to other variables, and unsignificant path from in-game need satisfaction to negative affect are not shown to keep the presentation clear. Significance levels for unstandardized coefficients: * p<.05, **p<.001. Significance levels for standardized coefficients: *p<.01, **p<.001.

Confirming the hypothesis 1e, the relationship between daily real-life need satisfaction and positive affect was positive and significant (b=.99, p<.001, β=.46, S.E. =.095, p<.001, CI 95% = [27., .65]). The relationship between daily real-life need satisfaction and daily negative affect, was negative and significant (b=-.63, p<.011, β=-.24, S.E.=.091, p=.005, CI 95% = [-.44, -.08]). In other words, on days when gamers felt real-life need satisfaction above their daily average, their positive affect was above their daily average and their negative affect was below

their daily average. The relationships between daily in-game need satisfaction and positive and negative affect were not significant, meaning that daily in-game need satisfaction did not contribute to the daily positive and negative affect over and above other included variables, most notably daily real-life need satisfaction. This was contrary to the hypothesized relationships (hypothesis 1g). In further contradiction with the hypotheses, the relationships between daily real-life and in-game need satisfaction and gaming time (hypotheses 1a and 1c) and between daily gaming time and daily positive and negative affect (hypothesis 3a) were not significant. Only the control variable weekend had a significant relationship with gaming time, meaning that gamers tended to play more on the weekends. Altogether, the model explained 30.6% of variance in daily positive affect and 9.2% of variance in the negative affect.

Model 1.2 – real-life and in-game need satisfaction predicting vitality and physical symptoms

The second model was structured the same as the first model, but it included daily vitality and physical symptoms instead of positive and negative affect. The physical symptoms were measured by one item, which referred to the frequency of experienced headaches. The measurement model was again tested first, including only the latent variables, physical symptoms (it was not defined as a latent variable as it had only one item), covariates and gaming time and the covariances between them. This model fit the data well ($\chi 2(87) = 115.53$, p=.022; RMSEA=.018, CFI=.988, TLI=.971, SRMR=.029) and the structural model was fitted next. This model achieved a good fit ($\chi 2(87) = 115.76$, p=.021; RMSEA=.019, CFI=.987, TLI=.970, SRMR=.030).

The Figure 3. below provides a depiction of the model with the significant path coefficients.

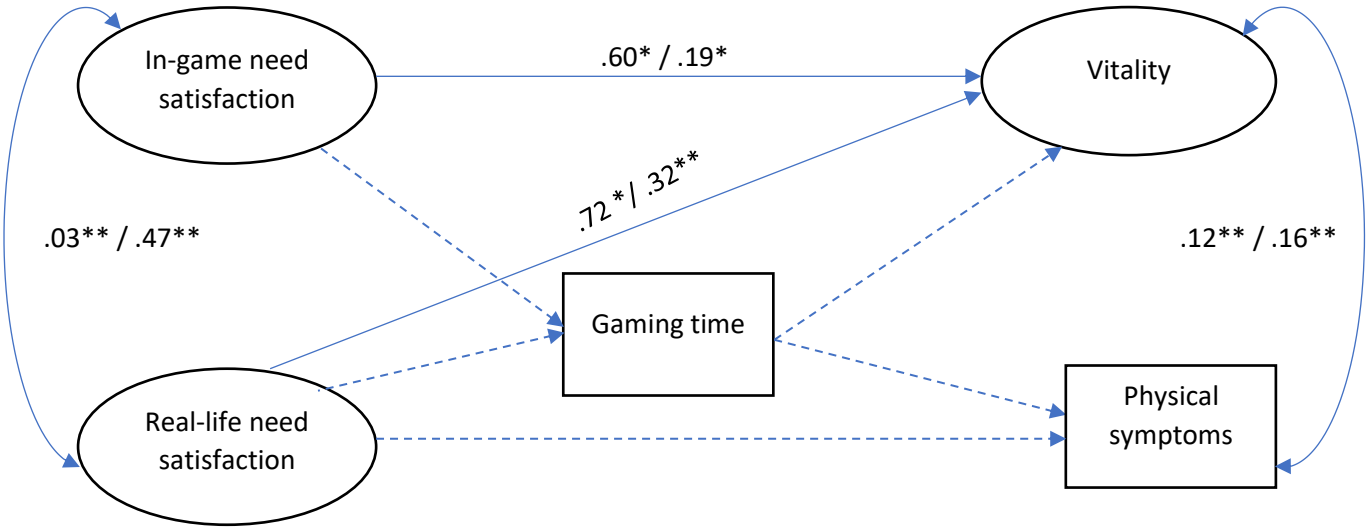

Figure 3. Model 1b. In-game and real life need satisfaction predicting vitality and physical symptoms directly and via gaming time.

*Note*. Values before the dashed lines represent unstandardized coefficients and values after the dashed lines represent standardized coefficients. Broken lines denote unsignificant paths. Paths from covariates "weekend" and "time" to other variables, and unsignificant path from in-game need satisfaction to physical symptoms are not shown to keep the presentation clear. Significance levels for both standardized and unstandardized coefficients: *p<.05,**p<.01.

The relationship between daily real-life need satisfaction and daily vitality was positive and significant (b=.72, p=.013, β=.32, S.E. =.107, p=.002, CI 95% = [.12, .53]), again confirming the hypothesis 1e, with regards to vitality as a different operationalization of well-being. On days when gamers' real-life need satisfaction was above their daily average, their vitality was above their daily average as well. Experienced daily in-game need satisfaction was also positively related to daily vitality above and beyond real-life need satisfaction (b=.60, p=.026, β=.19, S.E. =.080, p=.017, CI 95% = [.03, .35]). Therefore, on days when gamers' in-game need satisfaction was above their daily average, their vitality was above their daily average as well. Unlike vitality, daily physical symptoms had neither a significant relationship with daily-need satisfaction nor a significant relationship with in-game need satisfaction, and this part of the hypotheses 1e and 1g was thus not confirmed. The relationships between daily real-life and in-game need satisfaction and gaming time were like in model 1.1 again not significant, and thus the hypotheses 1a and 1c were not confirmed. Daily gaming time did not predict vitality nor physical symptoms and the hypothesis 3a was not confirmed with regards to these criteria. The control variable "weekend" predicted gaming time, in the sense that gamers played more on weekends, and it also predicted vitality, in the sense that they experienced more vitality on weekends. Altogether, the model explained 22.3% variance in vitality and 1.2% variance in physical symptoms.

Model 1.3 – real-life and in-game need frustration predicting positive and negative affect

The third and the fourth model had the same structure as the first two models, but they included daily real-life and in-game need frustration as predictors. Same as in the first model, daily positive and negative affect were included as the criteria in the third model. Measurement model was tested first, including only latent variables, control variables and gaming time and the covariances between them and it fit the data well ($\chi^2(233) = 413.55$, p<.001, RMSEA=.028, CFI=.970, TLI=.934, SRMR=.037). The structural model was fitted next and it fit the data well ($\chi^2(233) = 410.72$, p<.001, RMSEA=.029, CFI=.970, TLI=.934, SRMR=.037).

Figure 4. provides a depiction of the model with highlighted significant relationships.

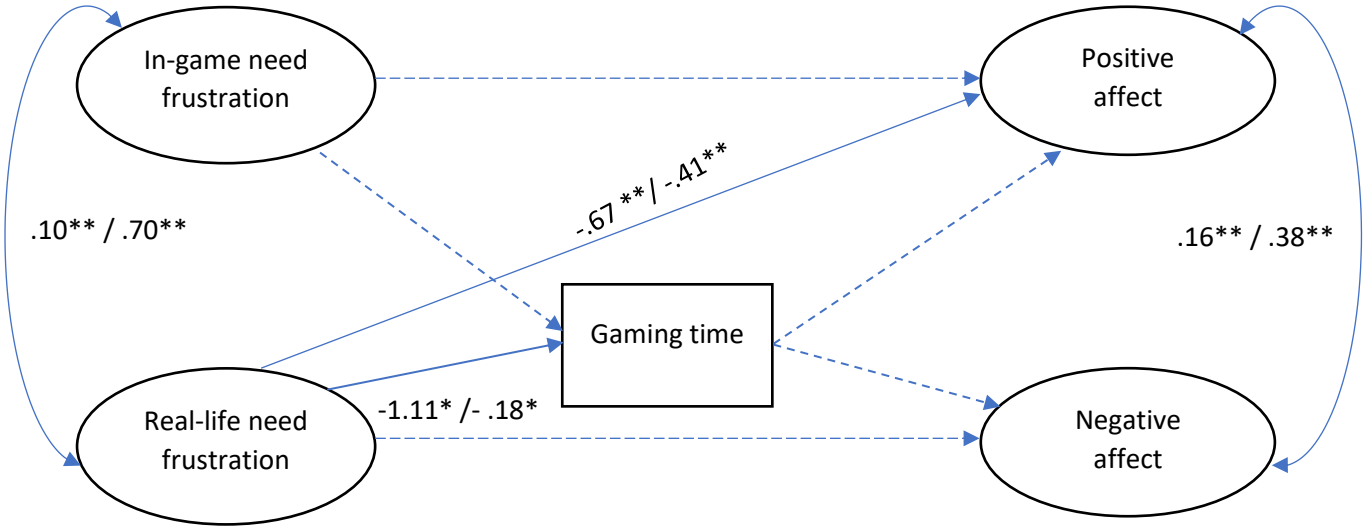


Figure 4. Model 1c. Daily in-game and real life need frustration predicting daily positive and negative affect directly and via gaming time.

*Note*. Values before the dashed lines represent unstandardized coefficients and values after the dashed lines represent standardized coefficients. Broken lines denote unsignificant paths. Paths from covariates "weekend" and "time" to other variables, and the unsignificant path from in-game need satisfaction to negative affect are not shown to keep the presentation clear. Significance levels for unstandardized and standardized coefficients are: * p<.05, **p<.01/p<.001.

Daily real-life need frustration was negatively related to daily positive affect (b=.67 p=.008, β=-.41, S.E. =.14, p=.003, CI 95% = [-.69, -.14]), and the hypothesis 1f was thus confirmed with respect to the positive affect as an operationalization of well-being. Daily real-life need frustration was however not related to the daily negative affect. On days when gamers felt real-life need frustration above their daily average, their positive affect was below their daily average. The relationship between daily real-life need frustration and daily gaming time was negative (b=-1.11, p=.041, β=-.18, S.E. =.087, p=.035, CI 95% = [-.36, -.01]), which was different than the hypothesized positive relationship (hypothesis 1d). In other words, on days when gamers felt a frustration of their real life needs higher than their daily average, they played less video games than their daily average. Other hypotheses were not confirmed as well, as there were no significant relationships between daily in-game need frustration and neither positive nor negative affect (hypothesis 1h). There was no relationship between daily in-game need frustration and gaming time (hypothesis 1b) and there were no relationships between daily

gaming time and positive and negative affect (hypothesis 3a). Altogether, the model explained 7.7% of variance in gaming time, 10.8% of variance in positive affect and 15.3% of variance in negative affect.

Model 1.4 - real-life and in-game need frustration predicting vitality and physical symptoms

In the fourth model, daily real-life and in-game need frustration were used as predictors and, as a parallel to the second model, daily vitality and physical symptoms in the form of headaches were used as the criteria. Measurement model was tested first, including the latent variables, physical symptoms, covariates, and gaming time and the covariances between them and it fit the data well ($\chi^2$ (135) = 217.13, p<.001; RMSEA=.025, CFI=.976, TLI=.946, SRMR=.036). The structural model was fitted next and it fit the data well ($\chi^2$ (135) = 215.51, p<.001; RMSEA=.026, CFI=.976, TLI=.946, SRMR=.036).

Figure 5. provides a depiction of the model with highlighted significant relationships.

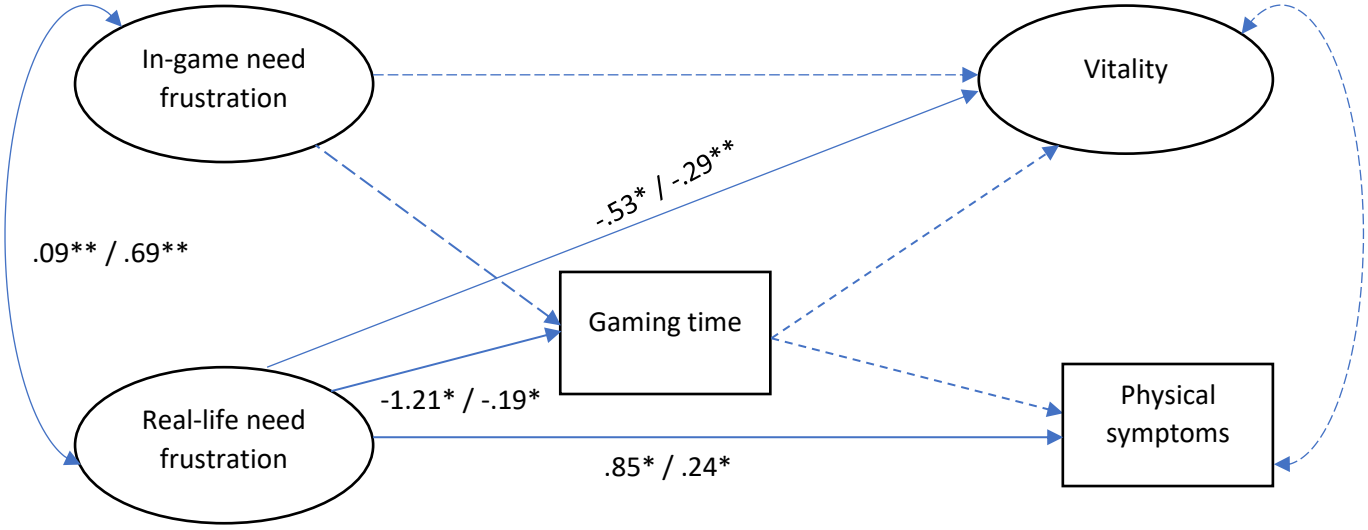


Figure 5. Model 1d. In-game and real-life need frustration predicting vitality and physical symptoms directly and via gaming time.

*Note*. Values before the dashed lines represent unstandardized coefficients and values after the dashed lines represent standardized coefficients. Broken lines denote unsignificant paths. Paths from covariates "weekend" and "time" to other variables, and unsignificant path from in-game need frustration to physical symptoms are not shown to keep the presentation clear. Significance levels for both standardized and unstandardized coefficients: * p<.05, **p<.01/p<.001.

The relationship between daily real-life need frustration and vitality was negative and significant (b=.53, p=.025, β=-.29, S.E. =.11, p=.009, CI 95% = [-.51, -.07]), and thus the hypothesis 1b was confirmed as well for vitality as an operationalization of well-being. In other

words, on days when gamers felt that their real-life needs were frustrated above their daily average, their vitality was below their daily average. The relationship between daily real-life need frustration and physical symptoms was negative and significant (b=.85, p=.022, β=.24, S.E.=.10, p=.014, CI 95% = [.05, .43], and the hypothesis 1h was as well confirmed with physical symptoms as an operationalization of well-being. On days when gamers felt that their real-life needs were frustrated above their daily average, they experienced an amount of physical symptoms which was above their daily average. As in the model 1c, the relationship between daily real-life need frustration and gaming time was negative (b=-1.21, p=.043, β=-.19, S.E. =.089, p=.036, CI 95% = [-.01, -.36]), which is in the opposite direction than hypothesised by hypothesis 1d. Other hypothesized relationships were not significant. There was no significant relationship between daily in-game need frustration and gaming time, and the hypothesis 1b was not confirmed. There were no significant relationships between daily gaming time and vitality and physical symptoms, and the hypothesis 3a was thus not confirmed. There were several significant relationships between the control variable weekend and other daily variables, showing as in other models that participants played more videogames and experienced more vitality during the weekend. In this model, the relationship with physical symptoms was significant as well, meaning that participants experienced fewer physical symptoms during the weekend. Altogether, the model explained 9.5% of variance in vitality and 7.2% of variance in physical symptoms.

Model 1.5 – real-life and in-game need satisfaction predicting positive and negative consequences of video games

In the fifth model, daily real-life and in-game need satisfaction were used as predictors, and daily positive and negative consequences of video game playing were used as the criteria. As in the previous models, daily gaming time was used as the mediator. Daily positive and negative consequences of video games are one-item indicators that measure gaming-related well-being and are thus represented as manifest variables. As mentioned in the instruments section, positive consequences of video games refer to perceived daily positive effects of playing video games, such as learning English or socializing and negative consequences of video games refer to daily perceived negative effects of video games, such as neglecting other important activity because of playing video games. Measurement model was tested first, including the daily real-life and in-game need satisfaction latent variables, daily gaming time and the daily positive and negative consequences of video game playing and the covariances between all variables in the model. This model fit the data well ($\chi^2$ (61) = 68.28, p=.24;

RMSEA=.011, CFI=.995, TLI=.988, SRMR=.027) and the structural model was fitted next. The structural model fit the data well ($\chi^2$ (61) = 67.90, p=.25; RMSEA=.011, CFI=.995, TLI=.988, SRMR=.028).

Figure 6. provides a visualization of the model with highlighted significant relationships.

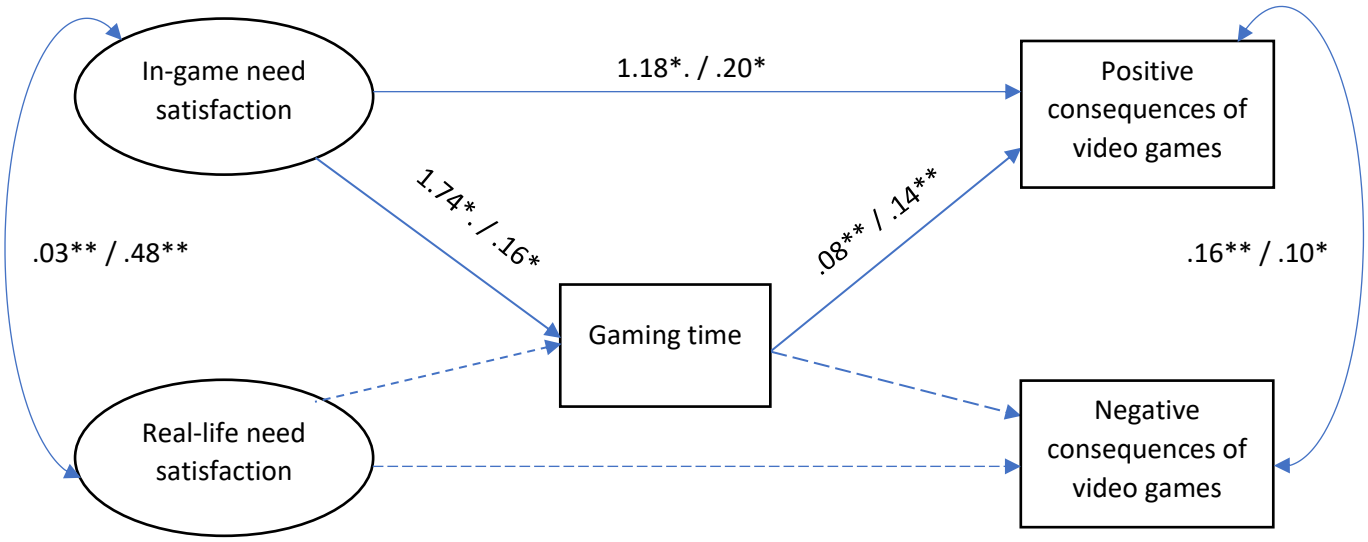


Figure 6. Model 1e. In-game and real life need satisfaction predicting positive and negative consequences of video games directly and via gaming time.

*Note*. Values before the dashed lines represent unstandardized coefficients and values after the dashed lines represent standardized coefficients. Broken lines denote unsignificant paths. Paths from covariates "weekend" and "time" to other variables, and unsignificant path from in-game need frustration to negative consequences of video games are not shown to keep the presentation clear. Unstandardized coefficients: *p<.05, **p<.01. Standardized coefficients: *p<.05, **p<.01.

Unlike in previous models where daily real-life need satisfaction was robustly related to daily well-being, the hypothesis 1e about a positive connection between daily real-life need satisfaction and daily positive consequences of video games as a variant of gaming-related well-being was not confirmed. However, daily in-game need satisfaction was positively related to daily positive consequences of video gaming (b=-1.18, p=.026, β=.20, S.E. =.086, p=.022, CI 95% = [.03, .37]), which confirmed the hypothesis 1g about a contribution of daily in-game need satisfaction to daily well-being, here in the form of gaming-related well-being. Specifically, when daily in-game need satisfaction increased above the daily average, positive consequences of playing video games increased above the daily average as well. Daily in-game need satisfaction was related to daily gaming time, and the relationship was positive (b=1.74, p=.04, β=.16, S.E. =.07, p=.027, CI 95% = [.02, .30]), thus confirming the hypothesis 1a about

in-game need satisfaction being positively related to gaming time. When daily in-game need satisfaction increased above the daily average, daily gaming time increased above the daily average as well. In this model, daily gaming time was significantly related to one of the criteria, which confirmed the corresponding hypothesis 3a. Specifically, it was positively related to daily positive consequences of video games (b=.08, p=.001, β=.14, S.E. =.042, p=.001, CI 95% = [.06, .22]), but not related to the daily negative consequences of video games, although this positive relationship was close to significance (b=.04, p=.06, β=.065, S.E. =.035, p=.06, CI 95% = [-.003., .13). Since both real-life need satisfaction was related to gaming time and gaming time was related to positive consequences of video games in this model, an indirect effect was computed from real life needs satisfaction to positive consequences of video games. This indirect effect was computed while using Bayesian estimation (Muthen & Asparouhov, 2012), since the population distribution of indirect effects is not normal, and Bayesian estimation is one of the ways to compute an indirect effect in multilevel models (Muthen & Asparouhov, 2012). This effect was significant according to the one-tail significance test (b=.16, p=.022, 95% CrI = [.001 - .44]), but its credibility interval was very close to zero, and therefore the effect will not be interpreted. Real-life need satisfaction was, as in other models, not significantly related to gaming time, thus rejecting the hypothesis 1c. This model explained 7.8% of variance in gaming time, 10.1% of variance in positive consequences of video games and 1.4% of variance in negative consequences of video games.

Model 1.6 - real-life and in-game need frustration predicting positive and negative consequences of video games

In the sixth model, daily real life need frustration and daily in-game need frustration were used as the predictors, and, analogous to the model 1e, positive and negative consequences of video games were used as the criteria. Gaming time was used as the mediator. A measurement model including these four variables, covariates, and gaming time and covariances among them was tested first, and it showed a good fit to the data ($\chi^2$ (103) = 164.74, p<.001; RMSEA=.025, CFI=.977, TLI=.945, SRMR=.036). The structural model was fitted next, including the predictive relationships, and it provided a good fit to the data as well ($\chi^2$ (103) = 157.56, p<.001; RMSEA=.028, CFI=.975, TLI=.939, SRMR=.038).

Figure 7. provides a visualization of the model with highlighted significant relationships.

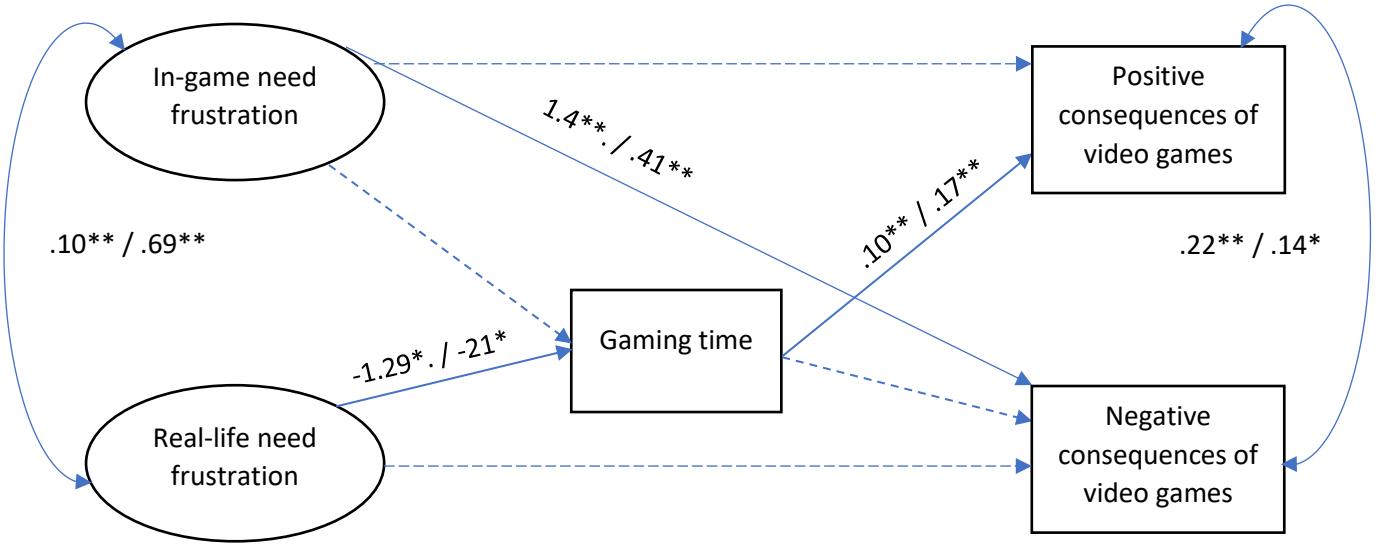


Figure 7. Model 1f. In-game and real-life need frustration predicting positive and negative consequences of video games directly and via gaming time.

*Note*. Values before the dashed lines represent unstandardized coefficients and values after the dashed lines represent standardized coefficients. Broken lines denote unsignificant paths. Paths from covariates "weekend" and "time" to other variables, and unsignificant path from real-life need frustration to positive consequences of video games are not shown to keep the presentation clear.. Unstandardized coefficients: *p<.05, **p<.01. Standardized coefficients: *p<.05, **p<.001.

Daily real-life need frustration was not related to daily negative consequences of video games, unlike in the previous models where it was related to operationalizations of well-being. The hypothesis 1e was thus not confirmed in this case where subjective daily consequences of video games were measured. Daily in-game need frustration was related to daily negative consequences of video games (b=1.4, p=.001, β=.41, S.E. =.11, p<.001, CI 95% = [.20, .63]), which confirmed the hypothesis 1h about the incremental contribution of in-game need frustration in the case of this well-being operationalization. Real-life need frustration was, as in models 1c and 1d, negatively related to gaming time (b=-1.29, p=.023, β=-.21, S.E. =.09, p=.017, CI 95% = [-.38, -.04]), which was contrary to the hypothesis 1d. In-game need frustration was not related to gaming time, which was also contrary to the hypothesis 1b. Gaming time was, as in model 1e, positively related to positive consequences of video games (b=.10, p<.001, β=-.17, S.E. =.04, p<.001, CI 95% = [.09, .26]) and the hypothesis 3a was again confirmed in this model. Since both real-life need frustration was related to gaming time and gaming time was related to positive consequences of video games in this model, an indirect effect was computed from real life needs frustration to positive consequences of video games. This effect was computed with the Bayesian estimation as in the model 1.5, and it was significant according to the one-tail significance test (b=.16, p=.014, 95% CrI = [-.30 - -.01]),

but its credibility interval was very close to zero, and therefore the effect will not be interpreted. The relationship of daily gaming time to the daily negative consequences of video games was also not significant and the hypothesis 3a was not confirmed with regards to this operationalization. The model explained 8.1% of variance in gaming time, 4% of variance in positive consequences of video games and 13.4% of variance in negative consequences of video games.

#### 3.3.2.2 A summary of models answering the first research question

Daily in-game need satisfaction was only significantly and positively related to gaming time (hypothesis 1a) in model 1.5, where daily positive and negative consequences of video games were the criteria. In models 1.1 and 1.3 this relationship was not significant. Daily real-life need satisfaction and in-game need frustration were not related to gaming time. The hypotheses 1c and 1b were not confirmed. Daily real-life need frustration was negatively related to daily gaming time consistently across models 1.3, 1.4 and 1.5, which was in opposite direction than hypothesized in hypothesis 1d.

Altogether, experienced daily real-life need satisfaction was positively related to daily positive affect and negatively related to negative affect, as well as positively related to experienced daily vitality (models 1.1 and 1.2). This confirmed the hypothesis 1e about a positive relationship of daily real life need satisfaction and daily well-being. This hypothesis was not confirmed only in the case of daily perceived positive consequences of video games (model 1.5), as daily experienced real-life need satisfaction was not related to it.

Daily real-life need frustration was negatively related to daily positive affect (model 1.3) and daily vitality (model 1.4), and positively related daily physical symptoms in the form of headaches (model 1.4). However, it was not related to daily negative consequences of video games (model 1.6). The corresponding hypothesis 1f was partially confirmed.

Daily in-game need satisfaction contributed to experienced daily vitality above and beyond daily real-life need satisfaction and daily gaming time (model 1.2) but did not contribute to the daily positive affect (model 1.1) nor to daily physical symptoms (model 1.3). It contributed to the daily perceived positive consequences of video games (model 1.5). The corresponding hypothesis 1g was therefore partially confirmed.

Daily in game need frustration was not related to any of the well-being criteria (positive and negative affect, vitality, physical symptoms) but it was related to perceived daily negative consequences of video games (model 1.6). The corresponding hypothesis 1h was confirmed only with respect to this operationalization.

Gaming time was not related to either positive and negative affect or to the vitality and physical symptoms in any of the models. Gaming time was positively related to daily positive consequences of video games in models 1.5 and 1.6. The hypothesis 3a concerning the relation of gaming time to well-being criteria was confirmed only with respect to daily perceived positive consequences of video games.

To summarize the answer to the first research question, gaming time was predicted by daily real life needs frustration across different models, but this relationship was negative, meaning that when gamers felt that their needs were frustrated above their daily average, they played video games below their daily average. Real-life and in-game psychological need satisfaction and frustration directly predicted different operationalizations of well-being, with real-life need satisfaction and frustration being stronger and more robust predictors than in-game need satisfaction and frustration across different well-being operationalizations. Unlike real-life need satisfaction and frustration, in-game need experiences predicted only vitality (in-game need satisfaction) and gaming-related well-being. The indirect paths from daily in-game or real life need satisfaction or frustration to well-being via gaming time were not supported by the data in any of the models. On the criterion side, daily gaming time was significantly related only to perceived positive consequences of video games, and it was not related to positive and negative affect, vitality and physical symptoms.

3.3.2.3 Second research question – psychological needs, gaming time and sleep

1. Do psychological need satisfaction and frustration in games and in real life predict sleep, both directly and indirectly through gaming time?

To answer the second research question, two models were built: each using either daily life satisfaction or frustration as predictors, daily gaming time as the mediator and daily objective and subjective sleep as the criteria. As previously mentioned, daily sleep quality and sleep quantity were measured in the morning, thus being temporally separated from daily need satisfaction or frustration and daily gaming time, which were measured in the evening. Daily

sleep quality and quantity were lagged +1 in the dataset to create this separation, i.e., that the variables measured in the evening predict those measured on the following morning. Total gaming time was also computed differently than in previous models to obtain the correct temporal order of variables. Namely, it was computed by adding the gaming time in three time blocks (6 am to Noon, Noon to 6 pm and 6 pm to Midnight) from the evening measurement on one day and gaming time in the first block (Midnight to 6 am) obtained from the evening measurement on the following day. To achieve this in a technical sense, the item measuring gaming time from Midnight to 6am was lagged +1. This means that gaming time in three blocks (altogether 6am to Midnight) from Day 1 was joined with the gaming time in the first block (Midnight to 6am) from Day 2, and this sum of gaming time then predicted sleep on Day 2, and this was repeated for each following day.

"Time" and "weekend" were again used as covariates. However, "time" was now split into two variables, one for morning and one for evening surveys, because morning and evening surveys were consistently administered at different times of the day and number of morning and evening surveys a participant has filled in since the study beginning was not necessarily the same.

Model 2a

In the first model, daily real-life and in-game psychological need satisfaction were entered as predictors, daily gaming time was the mediator and daily sleep quality and sleep quantity were the criteria. As in previous models, the measurement model was tested first, including the mentioned variables and only the covariances between them. This model showed a good fit to the data ($\chi^2$ (61) = 86.65, p=.02; RMSEA=.021, CFI=.985, TLI=.963, SRMR=.031). The structural model was fitted next and it showed a good fit to the data ($\chi$2 (73) = 101.52, p=.015; RMSEA=.022, CFI=.983, TLI=.960, SRMR=.034).

The model is shown in Figure 8.

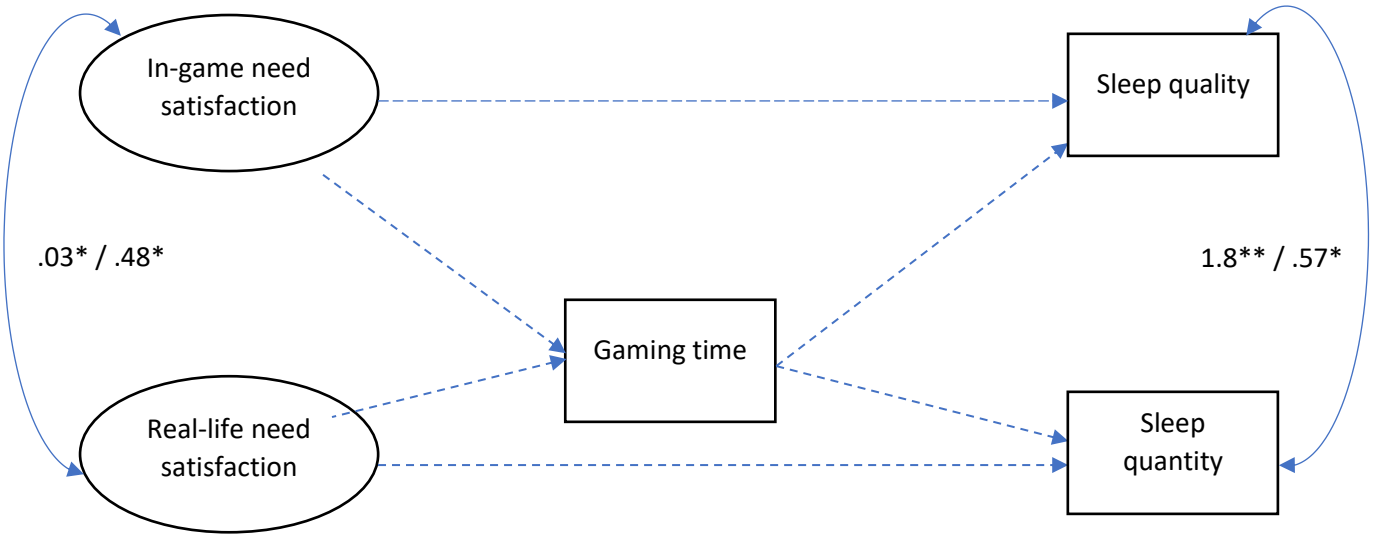


Figure 8. Model 2a. In-game and real life need satisfaction predicting objective and subjective sleep directly and via gaming time.

*Note*. Values before the dashed lines represent unstandardized coefficients and values after the dashed lines represent standardized coefficients. Broken lines denote unsignificant paths. Paths from covariates "time" and "weekend" to other variables, and unsignificant paths from in-game need satisfaction and real-life need satisfaction to the criterion variables are not shown to keep the presentation clear. Unstandardized coefficients: *p<.01, **p<.001. Standardized coefficients: *p<.01, **p<.001.

In this model none of the hypothesized relationships were significant. Specifically, daily in-game need satisfaction was related to neither objective nor subjective daily sleep (hypothesis 2d) and daily real-life need satisfaction was not related to any of the two criteria as well (hypothesis 2a). Daily in-game and real-life satisfaction were not related to daily gaming time and gaming time was not related to neither daily objective nor subjective sleep (hypothesis 3b).

Model 2b

In the second model, daily real-life and in-game need frustration were used as predictors, and analogous to model 2a, daily gaming time was the mediator and daily sleep quality and sleep quantity were the criteria. Measurement model showed good fit to the data ($\chi^2$ (118) = 160.75, p=.005; RMSEA=.019, CFI=..991, TLI=.981, SRMR=.033) and the structural model was fitted next. It showed a good fit ($\chi$2 (118) = 160.09, p=.006; RMSEA=.021, CFI=.984, TLI=.965, SRMR=.034) and it is shown in Figure 9.

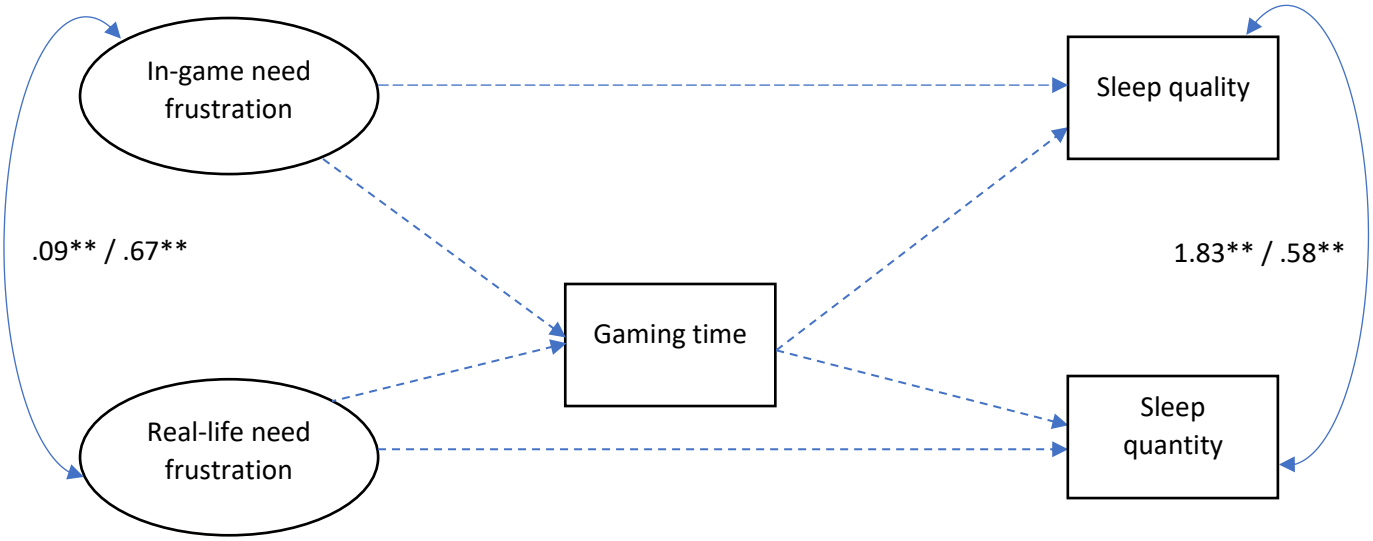


Figure 9. Model 2b. In-game and real life need frustration predicting objective and subjective sleep directly and via gaming time.

*Note*. Values before the dashed lines represent unstandardized coefficients and values after the dashed lines represent standardized coefficients. Broken lines denote unsignificant paths. Paths from covariates "time" and "weekend" to other variables, and unsignificant paths from in-game need frustration to sleep quantity and from real-life need frustration to sleep quality are not shown to keep the presentation clear. Weekend is coded as 0 = weekday, 1 = weekend day. Unstandardized coefficients: *p<.05, **p<.001. Standardized coefficients: *p<.05, **p<.001.

Same as in the model 2a, none of the hypothesized relationships were significant. Daily in-game need frustration was not related to either objective or subjective daily sleep (hypothesis 2c) and daily real-life need frustration was not related to any of the two criteria as well (hypothesis 2b). Daily in-game and real-life frustration were not related to daily gaming time and gaming time was not related to either daily objective or subjective sleep (hypothesis 3b).

To summarize the answer to this research question, daily psychological need in-game and real-life satisfaction and frustration did not predict sleep quantity and sleep quality, neither directly nor indirectly through gaming time.

3.3.2.4 Third research question – gaming time, well-being, and sleep

*3) Does gaming time predict well-being and sleep?*

It can be observed from models answering research questions 1) and 2) that gaming time did not predict well-being operationalized as positive affect, negative affect, vitality and physical symptoms in any of the models.

Only perceived positive and negative consequences of video games were predicted by gaming time, in the sense that gaming time positively predicted the positive consequences of playing video games in models 1.5 (with psychological needs satisfaction as predictors of gaming time) and 1.6 (with psychological needs frustration as predictors of gaming time). The hypothesis 3a was thus only confirmed with respect to this operationalization of well-being.

Gaming time did not predict neither sleep quantity nor sleep quality in models 2.1 and 2.2 and the hypothesis 3b was not confirmed.

To gain a deeper insight into relationships between gaming time and well-being and sleep criteria by examining interindividual variability, models 1e and 1f and 2a and 2b were firstly fitted again with random slopes for the relationships between gaming time and the criteria. The random slopes provide an insight into interindividual variability among the participants in within person relationships between the variables. Secondly, the role of several moderators suggested by previous research and theory in the relationships between gaming time and well-being and sleep was investigated: gaming disorder symptoms, self-control, harmonious and obsessive passion, and game genres. Only models 1e and 1f with positive and negative consequences of video games as operationalizations of well-being were used to fit random slopes and interactions, because other well-being operationalizations (e.g., positive and negative affect) were latent variables formed with multiple indicators and these models involving latent variable interactions could not be fitted, probably because such models are complex, involve a lot of parameters and require very large sample sizes to be identified. All models were fitted with Bayesian estimators, which can accommodate random slopes (Sadikaj et al., 2021). Fit indices are not available with Bayesian estimators; instead, the trace plots, Gelman-Rubin statistics and density plots are used to assess model convergence (Depaoli & Schoot, 2017). In the following analyses, for the sake of brevity, it is implied that there were no major problems related to model convergence unless noted differently.

Random slope for the relationship between gaming time and positive consequences of video games was statistically significant and its value was very similar to the value in the previous section where this effect was computed without the random slope: (b=.08, p=.001, β=.13, p=.001, CrI 95% = [.05, .21]) for the model 1e and (b=.09 p<.001, β=.16, p<.001, CrI 95% = [.08, .23]) for the model 1f. The variability of random slope for the unstandardized effect around its mean for approximately 95% of participants in model 1e was: [-.15, .30] and in model 1f it was [-.14, .32]. From these data we can observe that, although the average effect

for the relationship between gaming time and positive consequences of video games was slightly positive, there was some variability among the participants, with some of them even having slightly negative estimates. The figure 10 illustrates this by showing the distribution of individual unstandardized b parameters for the relationship between gaming time and positive consequences of video games in model 1e.

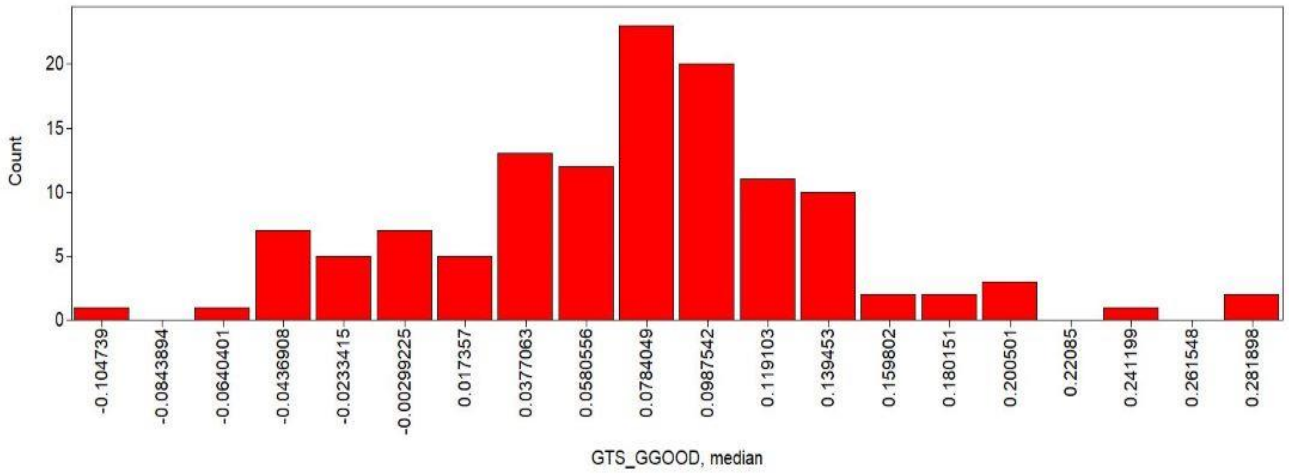


Figure 10. Distribution of individual participant unstandardized slopes for the relationship between gaming time and positive consequences of video games

Random slope for the relationship between gaming time and negative consequences of video games was not significant neither in model 1e nor in model 1f. The variability around it was nevertheless computed: [-.12, .12] in model 1e, and [-.12,.12] in model 1f, and it can be observed that it is lower than in the relationship between gaming time and positive consequences of video games.

None of the moderators (gaming disorder symptoms, self-control, harmonious and obsessive passion, and game genres) were statistically significant in explaining heterogeneity, i.e., the individual differences between participants in the relationship between gaming time and neither positive nor negative consequences of video games in models 1e and 1f.

Random slopes for the relationships between gaming time and sleep quality and quantity were not statistically significant in neither model 2a nor in model 2b. For the models to converge, separate models were created with sleep quality and sleep quantity. There was some interindividual variability of unstandardized slopes: [-.22 - .22] and [-.21, .21] for sleep quantity in models 2a and 2b and for sleep quality [-.20, .20] and [-.20, .20] in models 2a and 2b. Several moderators were tested (gaming disorder symptoms, self-control, harmonious and

obsessive passion, and game genres), and only obsessive passion was statistically significant in explaining the heterogeneity of the effects of gaming time on sleep quantity (Table 3 in Appendix B), but not on sleep quality (Table 4 in Appendix B). However, the boundary of the standardized credibility interval for this moderator effect was zero or very close to zero: [.000 - 1.012] in model 2 and [.001 - 1.068] in model 2b, and since many moderator relationships were tested, which increased the risk of the type I error, this effect was treated as non-significant.

In addition to fitting random slopes and testing moderators, the relationship between daily gaming time and daily sleep quality and quantity was explored by using the relevant gaming time segments instead of total gaming time. Specifically, models 2a and 2b were fit with gaming time from 6pm to midnight and then again with gaming time from midnight to 6am. All four models showed acceptable to good fits to data: 2a - 6pm to midnight ($\chi^2$ (73) = 110.80, p=.002; RMSEA=.025, CFI=.977, TLI=.947, SRMR=.035), 2b - 6 pm to midnight ($\chi^2$ (118) = 165.25, p=.003; RMSEA=.022, CFI=.981, TLI=.960, SRMR=.035), 2a - midnight to 6am ($\chi^2$ (73) = 93.98, p=.049; RMSEA=.019, CFI=.987, TLI=.970, SRMR=.031) and 2b - midnight to 6am ($\chi^2$ (118) = 160.98, p=.005; RMSEA=.021, CFI=.983, TLI=.964, SRMR=.033).

The relationship between gaming time from 6pm to midnight and daily sleep quality and quantity was not significant in neither of the models 2a and 2b. Daily gaming time from midnight to 6am was, however, significantly and negatively related to the amount of daily objective sleep in both models 2a and 2b, although the effect size was relatively small: model 2a (b=-.12 p=.040, β=-.07, p=.035, CI 95% = [-.135, -.015]), and model 2b (b=-.12 p=.039, β=-.07, p=.036, CI 95% = [-.140, -.022]). It was not related to subjective sleep.

In summary, the random slope for the relationship between gaming time and daily positive consequences of video games was significant and there was some heterogeneity in the individual effects between the participants. The random slope for the relationship between gaming time and daily negative consequences of video games was not significant. There was some variability between the participants in the individual effects, although considerably less than for the relationship between gaming time and positive effects of gaming. None of the moderators (i.e., gaming disorder symptoms, self-control, harmonious and obsessive passion, and game genres) explained the heterogeneity, i.e., the interindividual variability in neither the relationship between gaming time and the positive effects of gaming (Table 1 in Appendix B) nor the relationship between gaming time and the negative effects of gaming (Table 2 in

Appendix B). Random slopes for the relationship between gaming time and sleep quantity (Table 3 in Appendix B) and quality (Table 4 in Appendix B) were not significant. There was some interindividual variability in these effects, but it was not explained by any of the moderators. The relationship between gaming time and sleep was examined in more detail by focusing on late night gaming, and it was found that gaming time from midnight to 6am was slightly negatively related to objective, but not subjective, sleep.

# 4. DISCUSSION

This study examined the daily variations in real-life and in-game psychological need satisfaction and frustration, video game playing time and well-being and sleep of adolescent gamers. Its aim was to determine the relations between basic psychological needs and gaming time and well-being and between gaming time and well-being and sleep. The study addressed three questions: (1) Do psychological need satisfaction and frustration in games and in real life predict gaming time and well-being, both directly and indirectly through gaming time? (2) Do psychological need satisfaction and frustration in games and in real life predict sleep, both directly and indirectly through gaming time? and (3) Does gaming time predict well-being and sleep? In the following paragraphs, I will interpret the answers to these research questions from this study in the light of the theory and findings from other studies. I will highlight the study's limitations and strengths and draw theoretical and practical conclusions.

## 4.1 Predicting daily gaming time

In tested models, daily gaming time was predicted by in-game and real-life need satisfaction and need frustration.

In-game need satisfaction should theoretically increase daily gaming time and in-game need frustration should decrease it, which was represented in this model by hypotheses 1a and 1b. As discussed in the introduction, several studies have shown that experienced in-game need satisfaction was related to gaming time and there were no studies investigating in-game need frustration and gaming time, but this relationship was expected according to theory. However, the results were different than expected.

In-game need satisfaction was not related to daily gaming time in models 1.1 and 1.3, where the criteria were the positive and negative affect, vitality and physical symptoms. In-game need satisfaction was related to gaming time in model 1.5 where the criteria were positive and negative consequences of video games. In this case, in-game need satisfaction was related to gaming time with an unstandardized b coefficient of 1.74, meaning that for every one unit

increase above a person's daily average in in-game need satisfaction[6], a person's gaming time would increase for 1 hour and 44 minutes above their daily average. The standardized effect was 0.16, meaning that for a one standard deviation increase above a person's daily average in in-game need satisfaction, a person's gaming time would increase for 0.16 standard deviations above the daily average. In two models 1.1 and 1.3 where this relationship was not significant, it was in fact relatively close to significance (p=.08) and its b was 1.46, which is close to the one reported above. It is possible that due to the configuration of these models, which were more complex since they used latent variables as the criteria as well, there was not enough statistical power to capture the effects of in-game need satisfaction on gaming time. This relationship was obtained in previous studies, as already mentioned in the introduction. For example, Ryan et al. (2006) have shown in an experimental study that the satisfaction of psychological needs leads to longer playing times and Quist (2016) has shown in a daily diary study that the in-game satisfaction of psychological needs above daily average is related to longer playing times on that day. Quist's (2016) model included just the in-game need satisfaction and playing time, i.e., it did not take into account the real-life need satisfaction like the model used in this study. In any case, this study could not conclusively confirm the hypothesis 1a stating that there is a relationship between need satisfaction and gaming time. From a theoretical standpoint, it seems plausible that the more we satisfy our psychological needs while playing, the more we would want to play, because we enjoy the game more (e.g., Tamborini et al., 2010) and vice versa, the more we play, the more we would satisfy our psychological needs, because we would have more opportunity to do so. Indeed, the obtained b of 1.74 is relatively large, and it is possible that the relationship was not significant in models 1.1 and 1.3 simply due to lack of statistical power.

In-game need frustration did not predict gaming time in any of the models, disconfirming the hypothesis 1b. This relationship was surprisingly not directly tested in previous studies, but it would be expected from a theoretical standpoint that higher daily need frustration experienced in games would lead to less gaming time on that day. Namely, need frustration experienced in activities should decrease motivation and induce stress (Ryan & Deci, 2017). A study by Liao et al. (2016) has shown that in-game frustration (which was albeit not measured as

[6] In-game need satisfaction is a latent variable, and it does not have units of measurement by default, but they have to be set by the researcher (Brown, 2015). In this study, the metric of every latent variable was determined by its first indicator, i.e., it was fixed to be the same as the corresponding first indicator. This means that every unstandardized b coefficient involving latent variable(s) is interpreted as a change in the first indicator in the corresponding latent variable(s).

psychological need frustration) in gamers who play a game frequently is associated with dashed expectations and subsequently with a desire to quit the game. It may be possible that, since many adolescent gamers in this sample played online multiplayer games, they experienced some form of social pressure while playing (Krassen & Aupers, 2022), which would then keep them playing despite experiencing, for example, in-game autonomy frustration on a given day. Future studies are needed to clarify whether daily psychological need frustration experienced in games really leads to a reduction in gaming time, and if not, why. In a broader sense, it also seems that the meaning of the construct of psychological need frustration experienced within games is somewhat unclear. Video games are designed primarily to provide need satisfaction (Ryan & Rigby, 2011), but as discussed in the introduction, negative experiences of in-game need frustration can occur as well. This was evident in this study as the means of in-game need frustration items were lower than the means of the in-game need satisfaction items, but they centred around 2.5 and were similar to the means of the real-life need frustration items. In this study, I adapted items from the Basic Psychological Need Satisfaction and Frustration Scale (Chen et al., 2014) to measure in-game need satisfaction and frustration, and in the pilot study conducted prior to this study it was verified that the adolescent gamers in fact understood the meaning of these items. However, these items were simply adapted from items measuring real-life need frustration. I described in the introduction what the frustration of each individual need within video games should mean, but these ideas were never empirically examined on a sample of gamers. It would be useful to conduct a qualitative or a mixed methods study about the meaning of need frustration within both offline and online video games to better understand the forms that need frustration within games can take and to understand its meaning for the players. Finally, perhaps it would be apt to construct a new measure which would more adequately capture the construct of in-game psychological need frustration in contemporary video game playing. Although in-game psychological need satisfaction is a more researched construct, the same ideas for future studies could be applied for it, as its items were also simply adapted from items measuring real-life need satisfaction.

Besides in-game need satisfaction and frustration, in hypotheses c and d I hypothesized that their daily real-life counterparts, in particular real-life need frustration, would predict daily gaming time. Daily real-life need frustration was found to predict daily gaming time, but it was in an inverse direction than hypothesized. The finding does have a logical explanation that can be grounded in the empirical literature.

According to the need-density hypothesis (Ryan & Rigby, 2011), I hypothesized (hypotheses 1c and 1d) that gamers should play video games above their daily average on days when their need satisfaction is below average, and their need frustration is above average. However, an almost opposite pattern was observed in the results. Daily real-life need satisfaction was not related to daily gaming time and daily real-life need frustration was negatively related to daily gaming time in all models where it was examined, namely models 1.3, 1.4 and 1.6. The values of unstandardized betas were -1.11, -1.21 and -1.29 in models 1.3, 1.4 and 1.6 respectively and the standardized betas were -.18, -.19 and -.21. All coefficient values are similar, and I will provide an interpretation for the values of these coefficients observed in the model 1.4. Namely, on days when gamers' real-life needs were frustrated one unit above their daily average, they played video games 1.21 hours less than their daily average. To put it differently, when their real-life needs were frustrated one standard deviation above their daily average, they played video games 0.19 standard deviations less than their daily average. This is an interesting finding which is in accordance with what Allen (2020) found in their daily diary study on gamers and suggests that gamers tend to play less video games on days when their real-life needs are frustrated. The finding dovetails with what Razum and Huić (2023) found in their interview study conducted on adolescent gamers. Namely, adolescent gamers do not like to play competitive games to cope with negative feelings, because their performance would suffer and they perhaps rather play relaxing games, which better help them cope. Barr and Copeland-Stewart (2022) also found in their study on gaming during the Covid-19 pandemic that gamers played relaxing or "feel-good" games to help them cope with stress. Since the game genres that the participants in this study mostly played were competitive (e.g., Shooters, MOBA, Battle royale games), it is possible that this mechanism led to a reduction in their gaming time on days when their needs were frustrated. Specifically, on a day when their needs were frustrated, participants might have significantly reduced the time spent on playing a competitive game and potentially played a bit of relaxing games, which would have led to a reduction of gaming time on that day compared to a day when their needs were not frustrated. A study by Tyack et al. (2020) shows that this coping mechanism may be successful, as they have found that after gamers' competence was frustrated, gamers managed to restore their positive affect and vitality by playing a video game. In other words, on a daily level, adolescent gamers who are faced with real-life need frustration may both play less than usual, and this gameplay may help them cope with need frustration. However, in the longer run, those who have their real-life needs chronically frustrated and those how have chronically low real-life need satisfaction, may seek refuge in video gaming. These gamers may eventually develop problematic gaming. For them,

gaming may represent a maladaptive coping mechanism, and they could play excessively when their needs are frustrated, and not cope actively with the problem. Conversely, "highly engaged, but healthy gamers" have diverse coping mechanisms (Razum & Huić, 2023) and for them coping via video games could be both beneficial in the short term and not harmful in the long run. It would be most apt to test these hypotheses in a longitudinal study which would also include a daily diary part to enable assessing both the short-term and long-term effects simultaneously. Other than coping with real-life need frustration, which was related to a decrease in daily gaming time in this sample of gamers, daily need dormant states (Reeve et al., 2023) could potentially increase daily gaming time. In a recent paper, need dormant states were conceptualized by Reeve et al. (2023) as states in which needs are neither satisfied nor frustrated. Namely, if the environment is indifferent toward one's needs, they could become dormant (i.e., disconnected or switched to "off"). Dormant needs were found to predict behavioural disengagement in the school classroom (Reeve et al., 2023), but in the context of video gaming, dormant needs in real life could lead gamers to play video games which then provide readily available need satisfaction. Further studies are needed to verify if this mechanism exists.

All in all, we have observed a significant and non-trivial positive connection between in-game satisfaction and gaming time in one of the models and a negative connection between real-life frustration and gaming time in all models which included those variables. A one unit increase in in-game need satisfaction meant a 1 hour and 44 minutes increase in daily gaming time in the one model where this relationship was significant, and one unit increase in real-life need frustration meant a 1 hour and 13 minutes decrease in daily gaming time in all models. However, the percentage of explained variance of daily gaming time in each of these models, that also included control variables "time" and "weekend", was around 8%. The question remains which daily predictors can explain the large residual variation in daily gaming time. De Grove et al. (2016) pointed out that, according to the Social Cognitive Theory, repeated behaviour in stable contexts, which was consciously motivated in the beginning, tends to turn into habits to reduce the cognitive load. It is possible that the daily gaming behaviour of adolescent gamers is to a certain extent habitual in terms of how many hours per day they play. It then follows that, although need satisfaction in games and need frustration in real life predicted gaming time and other motivational factors from other theoretical approaches may also be relevant, perhaps the contextual factors which can disrupt routines are equally or more important in predicting daily gaming time. Contextual factors are, for example, whether the

weather outside is sunny or rainy (van Rooij et al., 2017), whether one's friends also play on that day or whether there is an exam tomorrow (Razum & Huić, 2023). Future daily diary studies could also consider the contextual factors when predicting the gaming behaviour.

To sum up this part of the discussion, in-game need satisfaction was not a consistent predictor of gaming time across models, and this may be due to lower statistical power. In-game need frustration did not predict gaming time, which may be because in-game need frustration does not divert adolescent gamers from playing, but it also may be true that this construct is not adequately measured. Real-life need frustration negatively predicted gaming time, which is contrary to the "need density" hypothesis. It may be that on the daily level gamers shy away from intense video games that they usually play when they feel real-life need frustration, and they instead play more relaxing games that help them unwind, which is corroborated by previous studies. In the long term those who feel chronic real-life need frustration may still turn to video games, which is an assumption that needs to be tested with longitudinal studies. It is also possible that daily dormant need states would actually lead to increased daily gaming in adolescents. Daily gaming may be to a large extent habitual, and future studies should also look into other predictors of gaming time, such as contextual factors, which may disrupt those routines.

Moving away from predicting daily gaming time, which was positioned as a mediator and was at the same time a criterion and a predictor, the central criteria in this study's theoretical model were well-being and sleep. As this is a part of the first research question, I will first consider models that predicted different forms of well-being.

### 4.2 Predicting daily well-being

In this study, the daily well-being was measured with the daily positive and negative affect, vitality and physical symptoms. Additionally, two more specific, gaming-related well-being constructs were assessed: the daily positive and negative consequences of video games. Since the general well-being and these gaming-specific constructs represent different concepts, I will first discuss results regarding the daily positive and negative affect, vitality and physical symptoms, which will then be followed by a discussion about the positive and negative consequences of video games as the criteria.

I hypothesized that daily real-life need satisfaction and frustration will predict the daily well-being, and these hypotheses (1e and 1f) were mostly confirmed with respect to daily positive and negative affect, vitality and physical symptoms. The only result that was contrary to the

hypotheses for these criteria was the fact that the real-life need frustration did not predict negative affect, which will be discussed later. Specifically, the daily real-life need satisfaction predicted positive affect with a standardized beta of 0.46, negative affect with a standardized beta of -0.26 and vitality with a standardized beta of 0.32. This meant that when gamers' daily real-life need satisfaction increased one standard deviation above their daily average, their positive affect increased for 0.46 standard deviations above their daily average, their negative affect decreased for 0.26 standard deviations below their daily average and their vitality increased for 0.32 standard deviations above their daily average. Daily real-life need frustration predicted positive affect with a standardized beta of -0.41, vitality with a standardized beta of -0.29, and physical symptoms with a standardized beta of 0.24. This meant that when the gamers' real life need frustration increased for one standard deviation above their daily average, their positive affect decreased for 0.41 standard deviations below their daily average, their vitality decreased for 0.29 standard deviations below their daily average, and their experienced headaches increased for 0.24 standard deviations above their daily average. Daily real-life need satisfaction and frustration were dominant in explaining the daily positive and negative affect, vitality, and physical symptoms of adolescents, because as I will discuss later, only in-game need satisfaction had a positive contribution to vitality, and in-game frustration and gaming time we not connected to any of these criteria. Thus, the effects of real-life satisfaction and frustration on the discussed well-being criteria were also purely direct and not mediated by gaming time. They show that daily psychological need satisfaction and need frustration are a potent predictor of daily well-being in adolescents. How happy, energized, or sad adolescents feel on a given day is substantially connected to how satisfied were their real-life psychological needs on that day, and how happy or energized adolescents feel and how often they feel headaches is substantially connected to how frustrated were their psychological needs on that day. However, these effects were somewhat different than expected according to the theory and scarce previous studies. The SDT (Ryan & Deci, 2017; Rodriguez-Meirinhos et al., 2019) postulates that need satisfaction will lead to positive outcomes such as higher well-being, but need frustration will lead to negative outcomes such as internalized and externalized problems. In the context of adolescents, Rodriguez-Meirinhos et al. (2019) have dubbed this the "bright and dark pathway of adolescents functioning". This distinction is important within the SDT because it enables the separation of need satisfaction and need frustration as distinct constructs, i.e., it helps show that need frustration is not just low need satisfaction. Namely, in the SDT research it was observed that need satisfaction predicts optimal psychological functioning but does not predict non-optimal psychological functioning equally well and this

is why a construct which would capture more intense experiences and explain ill-being better was created, i.e., the need frustration (Warburton et al., 2020). A daily diary study by Laporte et al. (2021) has shown that the daily need satisfaction experienced by adolescents predicts the daily positive affect and daily negative affect, but the daily need frustration is the strongest predictor of the daily negative affect. A meta-analysis by Stanley et al. (2021) has shown that need satisfaction is moderately associated with negative affect, but need frustration, which was not considered in this work, is expected to be a stronger predictor of the negative affect than need satisfaction (Ryan et al., 2023). In this study such distinction was not fully achieved because while real-life need frustration exclusively predicted the physical symptom of headaches, it did not predict the daily negative affect. Moreover, the daily negative affect was still significantly predicted by daily real-life need satisfaction. A possible explanation could be that the indicators of negative mental health such as the symptoms of psychiatric disorders were not assessed in this study, and we would expect them to be predicted dominantly by real-life need frustration. In adults, diary studies have shown that daily need frustration is a stronger predictor of daily experiences of depression, stress and anxiety than daily need satisfaction (Rouse et al., 2020). However, the negative affect, which was predicted by real-life satisfaction and not by real-life frustration in this study, is also involved in depression, anxiety and other forms of psychopathology (Clark & Watson, 1991; Dejonckheere et al., 2019). Therefore, the fact that it was not related to real-life need frustration in this study may point to a certain lack of differentiation of the real-life need satisfaction and need frustration on a daily level in adolescents. Further daily diary studies using the well-being criteria, but also negative mental health criteria (e.g., depression, anxiety) are needed to clarify these findings. Differentiation was achieved with regards to physical symptoms, which were predicted only by the real-life need frustration. The connection between daily real-life need frustration and daily physical symptoms in form of headaches in adolescents could be expected given the SDT propositions (Ryan & Deci, 2017), but it is also a novel finding since this connection was never tested in previous studies, neither on adolescents nor on adults. Previous daily diary studies that used physical symptoms as a criterion (Reis et al., 2000; Ryan et al., 2010) have shown that autonomy and competence need satisfaction were related to physical symptoms in university students (Reis et al., 2000), but also that there was no connection between daily experienced need satisfaction and physical symptoms in adults (Ryan et al., 2010). Daily need frustration, which is in this case a more potent predictor given that it should be associated to maladaptive outcomes, was never used. Huynh and Fuligni (2013) did show in a cross-sectional study that discrimination, which can be related to relatedness need frustration, is connected to

experiencing more physical symptoms in adolescents. The connection between real-life need frustration and headaches points to a detrimental everyday effect of need frustration which goes beyond psychological well-being. It would be interesting to study these effects in the long run as well and on a wider range of symptoms, and to examine the contribution of the frustration of individual needs to physical symptoms.

Unlike real-world psychological need satisfaction and frustration, in-game need satisfaction and frustration played a rather smaller role in predicting the daily well-being of adolescents, apart from predicting vitality.

After accounting for real-life need satisfaction and frustration, their in-game counterparts mostly did not have a unique contribution in explaining daily positive, negative affect and vitality and physical symptoms, which was contrary to the hypotheses 1g and 1h with respect to these criteria. The only significant relationship was the contribution of daily in-game need satisfaction to the daily vitality, with a standardized beta of 0.19. In other words, this meant that when a person's in-game need satisfaction increased by one standard deviation above their daily average, their vitality increased by 0.19 standard deviations above their daily average. This is not a small effect, especially when we take into account that the standardized beta of real-life need satisfaction in the same model was 0.32, which is larger, but not by a large margin. Allen (2020) obtained in his study that daily in-game need satisfaction contributed to daily well-being, but its effect was about 10 times weaker than the effect of daily real-life need satisfaction. However, he used a composite measure of well-being, which consisted of positive and negative affect, vitality, physical symptoms, life satisfaction, and stress. In this study I have obtained a more nuanced picture, by observing that there is no relationship of daily in-game need satisfaction to the daily positive and negative affect and physical symptoms, but there is a significant relationship to the daily vitality. In some previous studies, a relationship between in-game need satisfaction and affect was found (Sheldon & Filak, 2008; Johannes et al., 2021). However, in this study, the contribution of real-life need satisfaction and gaming time was controlled as well and only the relationship with vitality remained significant. This finding is intriguing because vitality is an eudaimonic component of well-being, as opposed to the positive and negative affect, which represent the hedonic component. As described in the introduction, hedonic well-being represents the maximization of pleasure and minimization of pain, whereas eudaimonic well-being represents flourishing and living up to one's potential (Disabato et al., 2016). Vitality is state of aliveness and energy and more so than that, it refers to a psychological experience of possessing enthusiasm and spirit (Ryan & Frederick, 1997).

A connection between experiencing in-game need satisfaction and experiencing vitality speaks about the potential of video games to foster eudaimonic well-being, in this case in form of energy and enthusiasm, in the real life of adolescents. Such an effect would represent a meaningful contribution to an adolescent's life (Rigby & Ryan, 2017) that would go beyond just being entertained while playing a video game and could potentially aid their psychosocial development (Adachi & Willoughby, 2013; Daneels et al., 2020). It adds evidence to the claim that video games are not just a frivolous pursuit and a "waste of time", as some researchers, policy makers and parents may think. On the contrary, they may be an ingredient in the positive development of adolescents (Adachi & Willoughby, 2013), just like sports or other organized activities. Of course, we are still not sure whether these effects are truly causal and how do they manifest in the long run, and this will be elaborated in detail in the limitations section. It is interesting to note that most other studies did not examine the effect of in-game need satisfaction on vitality or other eudaimonic constructs, but well-being was operationalized mainly through positive and negative affect, or through a composite of different variables as in the mentioned Allen (2020) study. An exception was an early and important experimental study by Ryan et al. (2006), where it was shown that game exposure can reduce vitality by inducing fatigue in participants, but if autonomy and competence needs are satisfied in-game, the vitality will in fact increase. More recently, a cross-sectional study by Kosa and Uysal (2022) has shown that in-game need satisfaction is related to vitality. These findings were obtained either in an artificial laboratory setting in the early 2000s or within a rudimentary cross-sectional design, and this study is the first to confirm them in a daily diary design, and within a contemporary video gaming setting. The contemporary online games emphasize the social component of video gaming. Kowert and Kaye (2018) state that online multiplayer games could be regarded as virtual "third places", where one can interact with others, but doesn't have to, and where both the creation of new social relations ("bridging") and the deepening of existing ones ("bonding") happens. The absence of many non-verbal cues can in fact be a good thing, because it can create a combination of trust and anonymity, which leads to a so-called "online disinhibition effect" (Suler, 2004) and stimulates open and intimate conversations (Kowert & Kaye, 2018). Some authors claim that this social component, which largely corresponds to the relatedness need, is in fact the driver of the video games positive influence on well-being (Halbrook et al., 2019). In this study I could not examine the connection of individual needs with well-being because I used a shorter questionnaire to measure in-game need satisfaction and frustration, which was more apt for a diary study, and it measured each need with just two items. Future research should further investigate individual needs and their

relationship to daily well-being in a daily diary design, which could involve an experimental component to provide more evidence for the causal relationships. Besides analysing the satisfaction of existing in-game needs, propositions were made to include additional need(s) that could account for the aspects of gaming experience that are currently not covered by autonomy, competence and relatedness need satisfaction. Oliver et al. (2015) suggested a new need for insight, which they found to be a separate construct from the three basic needs. The authors found that the autonomy and competence needs were associated with game enjoyment, but the fulfilment of the needs for relatedness and particularly insight were associated with game appreciation. Game appreciation is more than simple game enjoyment and refers to the in-game gratifications that are derived from contemplations about the meaning of life, questions of virtue and the human condition (Oliver, 2015). The need for insight taps into the game's ability to provide such deep and meaningful experiences than can be compared to those obtained in books or movies, but a video game player can become even more engrossed by being able to act and influence the course of the game (Oliver et al., 2015). However, Vansteenkiste et al. (2020) called for caution in allowing new needs to be added to the three established ones, and they offered five basic criteria and a four more associated criteria which would have to be met by the candidate need. It is yet to be seen if all the basic criteria of the need being psychological, essential, inherent, distinct and universal as well as the associated criteria of the need being pervasive, content-specific, directional and explanatory could be satisfied by the need for insight. Perhaps the need could be included only within the gaming context, but even this warrants further research. In any case, it would be interesting to examine if the need for insight explains additional variance over the three needs satisfied in-game in daily vitality and other well-being criteria.

Another intriguing question refers to the exact mechanism through which the in-game need satisfaction enacts its effects on well-being. Thomaes et al. (2017) have found that experiences of authenticity mediated the relationship between real-life need satisfaction and well-being in adolescents. In other words, adolescents who fulfilled their real-life psychological needs were truer to themselves, which lead to higher well-being, operationalized as positive and negative affect. A similar mechanism could be at play with in-game need satisfaction as it could also foster experiences of authenticity and subsequently a feeling of internal coherence and integrity and contribute to well-being both directly and indirectly through authenticity, as it was found by Thomaes et al. (2017). Alternatively, this mechanism could be reserved exclusively for real-life need satisfaction. Finally, in this study, the real-life need satisfaction was opposed to its in-

game counterpart. However, real-life need satisfaction also happens through different activities, as it was noticed by Allen (2020). Since adolescent gamers played video games for an average of 4 hours and 7 minutes daily during the duration of this study, they spent more time doing other activities in which they fulfilled their psychological needs. Future studies could offer a more detailed analysis, where daily activities of adolescents would be broken down and need satisfaction would be measured separately for the main activities. The contribution of need satisfaction in different activities to well-being could then be compared to the contribution derived from video games.

As opposed to the beneficial effect of the daily in-game need satisfaction on daily vitality, in-game need frustration did not have a significant connection with neither daily positive and negative affect nor with vitality. This finding could not be attributed to floor effects as in the Allen's (2020) diary study. Namely, the means of in-game need frustration items were lower than those of in-game need satisfaction items, but comparable to those of real-life need frustration items and centred around 2.5, which is not far from the theoretical mean of the 1-5 scale. I previously discussed how in-game need frustration was not related to gaming time as well, and this lack of significant relations could also be because this construct needs to be explored and potentially refined. Alternatively, it may be that the in-game frustration is related only to more "extreme" constructs that are indicative of psychopathology, such as the gaming disorder.

To sum up, daily real-life need satisfaction and frustration were dominant in explaining the daily well-being. Daily real-life need satisfaction predicted the daily positive and negative affect and vitality, and daily real-life need frustration predicted the daily positive affect, vitality and physical symptoms in the form of headaches. This confirms the general assumptions of the Self Determination Theory (Ryan & Deci, 2017) and the Basic psychological needs theory (Ryan & Deci, 2017) on a daily level in adolescents. It shows that the daily real-life need satisfaction predicts not only the daily hedonic well-being in the form of positive and negative affect, but also the daily eudaimonic well-being in the form of vitality in adolescents. As Ryan and Deci (2017) elaborate, it is not enough that a person is physically rested for them to feel energized (i.e., vital), but they also need to be fed with psychological nutrients, i.e., they need to fulfil their basic psychological needs. It has been shown in this study that fulfilling basic psychological needs in real life helps adolescents not only to feel good but also to be energized for the activities that they value and that are instrumental in achieving their goals (Ryan & Deci, 2017). Although we cannot conclude about long term effects, it is not hard to conceive

that these daily increases in vitality could lead to long-term positive developmental outcomes (Vansteenkiste et al., 2020). Countering the positive effects of daily real-life need satisfaction, daily real-life need frustration was negatively related to vitality and additionally positively related to the experienced daily headaches. Adolescents who are depleted of energy and suffer from headaches can hardly be able to efficiently strive toward their goals. This is the first study that shows a link between real-life need frustration and headaches. The diminishing of vitality and increased headaches provide a pathway through which daily real-life need frustration could exert its negative effects on adolescents and potentially lead to the development of negative outcomes such as psychopathology over time (Ryan & Deci, 2017).

Contrary to the theoretical predictions, real-life need frustration did not predict the daily negative affect, which may point to a certain lack of differentiation between this construct and the real-life need satisfaction in adolescents, but for a more complete picture, negative mental health constructs (e.g., depression) should be included in future studies. In-game need satisfaction predicted daily vitality next to the real-world need satisfaction, while in-game need frustration was not related to any of the criteria. The connection between in-game need satisfaction and vitality reveals that games as well can contribute to our eudaimonic well-being. The potential of video games to be rejuvenating and contribute to higher levels of energy in adolescents on a daily level above the real-life experiences tells a compelling story about the positive effects of video games, which happen via the satisfaction of in-game needs. Future studies should consider the satisfaction of individual in-game needs as predictors of well-being, especially the role of the relatedness need. A new possible need for insight could be considered as a predictor of well-being, as well as mediators in the relationship of in-game need experiences and well being, such as authenticity. For a more fine-grained analysis, satisfaction of needs in real-life could be broken down to different activities and compared with satisfaction of needs in video games. Additionally, a previous study by Milyavskaya et al. (2009) has investigated the imbalance of need satisfaction in adolescents and found that those adolescents who have imbalanced need satisfaction across different domains (i.e., home, school, and friends), also have lower well-being in terms of positive and negative affect. In other words, need (im)balance predicted well-being over and above need satisfaction. It would be interesting to study this concept, while including video games as one of the activities.

Besides general well-being, in this study I assessed the contribution of daily need experiences to gaming-specific well-being in form of positive and negative consequences of video games. Unlike general well-being, in-game need experiences predicted these criteria. In fact, in models

using positive and negative consequences of video games as the criteria, both in-game need satisfaction was related to positive consequences of video games and in-game need frustration was related to the negative consequences of video games, which confirmed hypotheses 1g and 1h with respect to these criteria. These effects were purely direct and not mediated through gaming time. Conversely, real-life need satisfaction and frustration were not related to the positive and negative consequences of video games. These criteria were different than the previously assessed forms of well-being because they included the gamer's subjective assessment of the effects that playing video games on that day had on them. They were therefore, unlike the positive and negative affect, vitality and physical symptoms that represent global assessments of one's well-being, by definition put into a relation to video games. This gave them a narrower, but also a more precise focus. As mentioned, in-game need satisfaction was significantly related to the positive effects of video games. It had a standardized beta of 0.20, meaning that for an increase of one standard deviation above the daily average in in-game need satisfaction on a given day, gamers felt an increase in positive consequences of video games of 0.20 standard deviations above the daily average on that day. The unstandardized b was a sizeable 1.18, meaning that for every one unit increase above the daily average in in-game need satisfaction that the gamers felt, they felt a 1.18 unit increase above the daily average in positive consequences of video games. This meant that when gamers satisfied their needs within video games on a given day, they not only felt more vital, i.e., more energetic and enthusiastic, but they also felt that playing video games on that day brought them good things, such as learning something new or hanging out with others. This is a novel finding as it connects the in-game need satisfaction with some of the concrete video game effects and provides a theoretical background to experiencing those effects. An assessment and/or manipulation of in-game need satisfaction could be incorporated into experiments examining the effects of video games on cognition, mood and other criteria. Such studies would then not only answer the question of whether a certain type of games for example improve mood, but a possible working mechanism would be given that could at least partially explain this effect. For example, Adachi and Willoughby (2017) have found that playing strategic games improves problem solving skills via the experiences of autonomy and competence. Unlike in-game need satisfaction, real-life need satisfaction was not related to positive consequences of video games. It is possible that the narrowness of this criterion limited it to a connection with in-game need satisfaction, which is the most logical one. Also, in-game need satisfaction was not related to the perceived negative consequences of playing video games, meaning that higher experienced

in-game need satisfaction neither protected gamers from experiencing the daily negative consequences, nor made them more prone to them.

Instead, in-game need frustration was related to the negative consequences of video games with a standardized beta of 0.41 and an unstandardized b of 1.4. In other words, when in-game need frustration increased for one standard deviation or one unit above the daily average, the negative consequences of video games increased for 0.41 standard deviations or for 1.4 units above the daily average. This is an interesting finding since in-game need frustration was not related to neither gaming time nor to positive and negative affect and vitality and physical symptoms, but it was related to the negative consequences of video games. Negative consequences of video games referred to a subjective assessment of an adolescent gamer that video games had a negative effect on them on that day, i.e., that because they played video games on a given day, they did not have enough time for other important activities such as studying, going out with friends, doing other hobbies or doing sports. As mentioned in the introduction, it is an item which has similarities to the functional impairment criterion of Gaming Disorder (WHO, 2022) or Internet Gaming Disorder (American Psychiatric Organization, 2013), but it is specifically tailored to the daily lives of adolescent gamers. The question remains of how to interpret the connection between in-game need frustration and negative consequences of video games. It is possible that a gaming experience in which adolescents felt a frustration of their psychological needs was so negative that it spilled over into their real life, and because of it they did not have time for an important activity they wanted to do on that day. Since the two variables have a large standardized covariance of 0.70, a spillover in direction from real-life to in-game need frustration is also plausible. Finally, the negative consequences of video games could in fact cause the in-game need frustration. In that scenario, a gamer would decide to play even if they know they should not, because, for example, they have an exam on the following day. They could then feel guilty and nervous during gameplay and could be more prone to experiencing in-game need frustration. Further studies are needed which would disentangle the relationship of daily in-game and real-life need frustration and daily negative consequences of video games. They could also explain the fact that in-game need frustration is not related to the general well-being indicators, but it is related to the negative consequences of video games. It is possible that the negative consequences of video games play a mediating role in the relationship between in-game need frustration and the general well-being indicators.

All in all, daily positive and negative affect, vitality and the physical symptom of headaches were predicted largely by daily need satisfaction and daily need frustration, that seem to be the main determinants of adolescent daily well-being. In-game need satisfaction did have a notable contribution to predicting daily vitality, i.e., to how energetic and enthusiastic adolescents felt on a given day. Additionally, in-game need satisfaction and frustration predicted the daily positive and negative consequences of video games. Besides well-being, this study also included sleep as a criterion.

### 4.3 Predicting daily sleep

Neither real-life need satisfaction nor real-life need frustration predicted daily sleep quality or sleep quantity, and the hypotheses 2a and 2b were not confirmed. These relationships were also not mediated through gaming time. This is somewhat contrary to the results of recent studies, as they have shown a connection between the satisfaction and frustration of psychological needs and fulfilment of different physiological needs, among which is sleep (Vansteenkiste et al., 2020). As mentioned in the introduction, there is evidence from cross-sectional and two-wave studies that need frustration is related to poorer sleep quality (e.g., Uysal et al., 2020) and that need satisfaction is related to lower sleep duration (Tavernier et al., 2019). However, a recent diary study by Campbell et al. (2021) conducted on adolescents has shown that need frustration was mostly not directly related to sleep quality and sleep quantity, but this relationship was mediated through daily fatigue and stress. It is possible that at the daily, within person level, there is no direct connection between need satisfaction and frustration and sleep indicators, but that this connection appears in cross sectional and other studies that in a greater measure capture the between level relations between variables. This might mean that the need frustration experienced during one day will not lead to sleep difficulties during that evening, but may lead to sleep problems over a longer period of time. It is also possible that the daily need frustration does lead to sleep problems within the same day, but the mechanism is indirect. As shown by Campbell et al. (2021), the relationship between daily need satisfaction and frustration and sleep may be mediated by daily fatigue or stress. If this was true, need frustration experienced on a given day would make a person more tired or stressed, which would worsen one's sleep. This dovetails with this study's findings, where a connection between daily need frustration and daily physical symptoms was obtained. Daily physical symptoms, i.e.,

experienced headaches, could in turn negatively influence sleep. More research is needed to elucidate these relationships.

The relationship between in-game need satisfaction and frustration and sleep was never examined and this is the first study to do so. Same as real-life needs, in-game need satisfaction and frustration were not related to sleep quality and quantity and there was no mediation through gaming time. Thus, the hypothesis 2c was not confirmed. Although it can be assumed that in-game need frustration experiences may linger on and disturb sleep, it seems that it was not the case. The fact that no relationship was observed makes sense since real-life need experiences did not show any relationship to sleep, and they had much stronger and consistent relationships to all well-being indicators (besides positive and negative consequences of video games) than in-game need satisfaction and frustration.

After discussing research questions that dealt with the relationships of need experiences and gaming time and well-being, and need experiences and sleep, the final research question dealt with the relationship of gaming time and well-being and sleep.

### 4.4 Gaming time predicting well-being and sleep

Gaming time did not predict any of the well-being criteria, except one criterion specifically tied to gaming: the positive consequences of video games. Gaming time contributed to positive consequences of video games with an unstandardized b of 0.08 and a standardized beta of 0.14. In other words, when gaming time increased by one unit (one hour) or one standard deviation above the person's daily average, the positive consequences of video games increased by 0.08 units or 0.14 standard deviations above the person's daily average. This is not a large effect, but it was significant, showing that with an increase in daily gaming time, a slight increase in daily positive consequences of video games, which were defined as learning something new, hanging out with others and other things, can be expected. Thus, both in-game satisfaction of psychological needs and to a smaller extent gaming time contributed to experiencing positive consequences from playing video games. Of course, this relationship can be reversed, and it can be true that experiencing positive consequences from playing video games on a given day can entice a gamer to play a bit longer. When a random slope was introduced for the relationship between gaming time and positive consequences of video games, it could be observed that this relationship varied between the participants up to a certain degree. Specifically, some participants had a stronger positive relationship between gaming time and positive consequences of video games and a part of them even had a negative relationship.

However, this heterogeneity could not be explained, or in other words this relationship was not moderated by the most played game genre on a given day, harmonious and obsessive passion, gaming disorder symptoms or self-control. This is probably because the heterogeneity was not that large, and many participants had an individual b which is relatively close to the already mentioned mean effect of 0.08. Although a significant mean effect was not obtained for the relationship between gaming time and negative consequences of video games, a random slope was fit in that model as well. It showed that the heterogeneity in this effect between individuals was even lower than the one observed for the relationship between gaming time and positive consequences of video games. The heterogeneity was not explained, i.e., the relationship was not moderated by neither most played game genre on a given day, harmonious and obsessive passion, gaming disorder symptoms or self-control. This shows that, after controlling for real-life and in-game daily psychological need-based experiences, there is essentially no relationship between daily gaming time and daily negative consequences of video games. In other words, when controlling for need satisfaction or need frustration, daily gaming time is not related to whether a gamer missed out on an important daily activity because of playing video games.

Regarding the positive and negative affect, vitality and physical symptoms, it could also be observed that gaming time was not relevant in predicting these criteria when real-life and in-game need satisfaction and frustration were taken into account. Real-life need-based experiences were crucial in predicting these forms of well-being, which speaks to the fact that it is not important how much adolescents play video games, but rather if they satisfy and not frustrate their psychological needs in real-life. These results shine a different light on previous studies about gaming time (e.g., Vuorre et al., 2022; Allen, 2020) and different outcomes, which only used gaming time as a predictor and did not control for real-life and in-game need satisfaction and frustration. This also reaffirms what researchers were already stating (Kaye et al., 2020), namely that gaming time and similar concepts by itself do not mean much. In their critique of the "screen time" concept, Kaye et al. (2020) stated that when researchers use theoretically informed approaches, other factors derived from those approaches tend to be more influential than screen time in predicting well-being. In other words, it is important how well an adolescent integrates gaming within the rest of their life, and this will probably be successful if the adolescent experiences high psychological need satisfaction and low need frustration in their life outside gaming. Further evidence comes from the previous qualitative work by Razum and Huić (2023), where it was found that adolescents who expressed a desire to reduce their

gaming time in fact often lacked activities outside gaming where they would satisfy their basic psychological needs. This model could be enhanced in future studies by self-control, and rather than being a moderator of the relationship between gaming time and well-being, it could play a mediating role between need-based experiences and well-being (Mills & Allen, 2019). Experienced need satisfaction could enhance the daily self-control, and experienced need frustration could diminish it and self-control would then contribute to the daily well-being. Initial support for this idea was given in a cross-sectional study by Mills and Allen (2019). This would mean, for example, that an adolescent gamer who experiences need frustrating experiences on a given day would have a harder time enacting self-control on that day and would subsequently forego studying at the expense of playing video games. Future studies should explore the role of daily self-control and its relationship with need-based experiences and well-being in adolescent gamers. The entire picture is probably complex, but the results of this study indicate that rather than gaming time, daily real-life need experiences and to a smaller extent in-game based experiences are relevant for the daily well-being of adolescent gamers.

Similarly to a lack of relationship with well-being, daily gaming time did not show a significant relationship to daily sleep quantity or sleep quality. A random slope was introduced for these two relationships as well, and although it was not significant, there was some interindividual variability in relationships between gaming time and sleep quality and between gaming time and sleep quantity, with some participants having slightly positive and some having slightly negative relationships. The tested moderators: most played game genre on that day, harmonious and obsessive passion, gaming disorder and self-control did not explain any of the heterogeneity in these effects. However, a more detailed exploration of the relationship between gaming during different periods of day and sleep revealed that there was a significant negative relationship between gaming time from midnight to 6am and sleep quality. The b of the relationship was -0.12 and the standardized beta was -0.07, meaning that for a one unit (one hour) or one standard deviation increase above daily average in gaming time after midnight, sleep quality decreased for 0.12 units or 0.07 standard deviations below the daily average. It is a small effect, since it means that it would take a little over four hours of gameplay after midnight to decrease sleep quality for half a unit on a scale from 0 to 10, which was used for its measurement. This is the first daily diary study to examine the relationship between daily gaming time and sleep. Previous cross-sectional studies have shown a negative relationship between gaming time and sleep (e.g., Exelmans & van den Bulck, 2015) and Lemola et al. (2011) have shown that gaming between 10pm and 6am was associated with depression and

that this effect was mediated by daytime sleepiness. However, a study by Orben and Przybylski (2020), where adolescents filled in time use diaries for one weekday and one weekend day, has shown that the negative relationship between technology use and sleep is very small in magnitude. Accuracy of measurement is very important in determining these relationships (Orben & Przybylski, 2020), since retrospective measurement can distort the relationship between gaming time and sleep. In this study, gaming time after midnight had an intraclass correlation of 0.28 and sleep quality had an intraclass correlation of 0.32, meaning that around 70% of all variation in these variables was due to variation within the same participant throughout the study days. It becomes clear then why it is not easy for a person to give an overall assessment of either gaming time or sleep and that using methodology such as diary studies is necessary not just because they provide access to within person relationships. In this study, it was found that gaming time after midnight is slightly related to worse sleep quality. However, the question is whether this effect is large enough to warrant further scientific attention and let alone recommendations or policy change (Orben & Przybylski, 2019; Ferguson, 2009). In South Korea, the "Shutdown law", which was enacted in 2011, banned gaming from midnight to 6am for those younger than 16 (Lee et al., 2017). In a paper analysing the effects of this policy, Lee et al. (2017) concluded that it managed to increase sleep duration of children and adolescents by only 1.5 minutes, which is an effect that does not justify the infringement of human rights that this policy brings upon. Razum and Huić (2023) have found in a qualitative study that adolescent gamers are mostly mindful of their sleep. This study shows that their sleep quality and quantity are not related to their gaming time in general and sleep quality is only slightly related to gaming time after midnight. Therefore, the main culprits for bad sleep most probably lie in factors other than gaming. As it was already discussed, psychological need experiences were also not related to sleep in this study. However, other studies found that caffeine and energy drinks intake was related to poorer sleep and caused a decrease in slow wave sleep (Owens et al., 2014). Chronical medical illnesses, in particular chronic respiratory illnesses, and mental health issues such as anxiety and stress were related to sleep difficulties (Owens et al., 2014). There is no data on adolescents specifically, but clinical studies have found that gamers who suffer from Gaming Disorder have sleep difficulties (Ko et al., 2020). Finally, early school start times were related to a reduction in sleep, and some studies have found that when schools started later, this led to more total sleep, less sleepiness, fewer concentration difficulties and better academic performance in adolescents (Alfonsi et al., 2020; Owens et al., 2014). Future studies investigating gaming and sleep in adolescents could examine the interaction of some of these factors such as caffeine

intake and mental health issues with gaming to examine whether, for example, gaming compounds the negative effect of caffeine on sleep. A recently published longitudinal study has also suggested a reversed direction in the relationship between sleep and associated factors, namely that insomnia symptoms predict later gaming disorder symptoms in adolescents (Liu et al., 2023). Gaming by itself does not seem to affect sleep in a practically significant way, but this finding should also be replicated in future studies with sufficient methodological quality.

## 4.5 Limitations

Although this study used daily diary methodology coupled with the SDT theoretical framework and a broad range of criteria, which makes it both methodologically strong and theoretically grounded, it still has limitations which should be considered when discussing its conclusions. These limitations can be grouped into daily diary design related issues, issues of measurement of the used constructs, and pre-registration, study power and generalizability issues.

### 4.5.1 Daily diary design related issues

The daily diary design, although it has advantages over other designs used in gaming research, has limitations which should be acknowledged. These are the issues of retrospective bias, the inability to conclude about causal influence of variables and the inability to assess the long-term effects.

#### 4.5.1.1 The still present retrospective bias

The daily measurement does reduce the retrospective bias, but it is still different than measuring the constructs *in the moment*, such as with the experience sampling methodology (Gabriel et al., 2018), which represents the least biased mode of measurement from that perspective. In the case of the daily diary designs, the participants still give an estimate for a certain variable for that entire day, and this can lead to bias in recollection. However, it was not possible to create a design which would measure the constructs within this study multiple times per day. Specifically, adolescents play video games only during certain periods of the day and it would be hard to capture this behaviour with an experience sampling design, as discussed in the introduction. Such measurement could also interrupt a gaming session and thus influence the natural behaviour of gamers. Furthermore, measuring sleep by definition occurs only one time per day. Measuring the psychological need experiences in the moment might also be inadequate since perhaps not in every moment we can assess how satisfied or frustrated all our needs are,

but it would take a larger period of time (e.g., several hours or a day) over which we could conduct such assessment. Experience sampling research with psychological needs has been conducted (e.g., Prentice et al., 2020) and it has produced plausible results, however, this potential issue has not been assessed.

#### 4.5.1.2 Inability to conclude about causal influence

A perhaps crucial limitation of the daily diary design used in this study is the fact that it is very hard to conclude anything about the causal influence of variables. This is due to two main reasons: the inability to establish temporal precedence in relationships between variables and the inability to exclude the influence of the third variables via experimental manipulation.

Temporal precedence could not be established because the within person relationships, although they were computed on data spanning eight time points, were computed on concurrently measured variables. To put it in simple terms, this meant that a within person relationship between two variables was computed as a correlation between average values of those two variables at each time point. The problem with this approach is that the two variables whose within person relationship we are assessing were measured at the same time at each time point and these concurrent relationships were entered into the analysis. This means that there is a risk of common method variance (Spector, 2019) or common method bias (Gabriel et al., 2018), namely that a factor such as mood experienced at a certain time point could have affected the assessment of both variables. This issue may not be of crucial importance (Spector, 2019). However, the main issue is that temporal precedence cannot be established, i.e., we cannot know if the variable *a* influenced the variable *b* or vice versa. A remedy for both of those issues would be to test a lagged or a cross-lagged relationship between the variables. Namely, if I computed a relationship between the two variables so that one variable would predict the other at the following time point, this would have allowed to hypothesize about a direction in the relationship between the variables. In such a case, at each time point, one variable would be paired with the other measured at the following time point and the within person relationship would be computed in such a way. An even stronger variant of this is the cross-lagged relationship (Gabriel et al., 2018), where variable *a* predicts variable *b* at the following time point, controlling for the variable *b* from a previous time point predicting itself at the following time point. At the same time the variable *b* predicts variable *a* at the following time point, controlling for the variable *a* from a previous time point predicting itself at the following time point. In such a way we can test which direction of the relationship is more

plausible, *a* to *b*, or *b* to *a*. However, none of these variants could be tested in this study, since it can hardly be expected that the measured variables predict each other from one day to another, because the temporal lag is relatively big. It is more apt to test such relationships within the experience sampling framework with multiple measurements within the same day, although they are rarely tested even within that framework (Gabriel et al., 2018). What this means for this study is that, since the lagged or cross-lagged relationships were not tested due to described issues, we cannot know if, for example in-game psychological need satisfaction influenced experienced vitality, if the relationship went from vitality to psychological need satisfaction or if the influence is mutual. We can assume that a direction from in-game psychological need satisfaction to vitality is more plausible based on theory and previous experimental studies (e.g., Ryan et al., 2006), but we cannot be sure about it.

However, besides the direction of the relationship, there is an even bigger issue germane to non-experimental designs, namely the possible influence of the third variables (Spector, 2019). This problem is not so critical as in cross-sectional studies and other studies that do not assess within person relationships, but it still exists. Specifically, since within person relationships were tested, between person third variables such as personality traits were not able to influence them (Gabriel et al., 2018), but these relationships were still susceptible to within person confounders. As explained in the results section, I tried to ameliorate this issue as much as it was possible. I controlled for whether a certain day is a weekday or a weekend day (the weekend variable) to control for possible confounding effects of the weekend, when a participant can, for example, both play more video games and experience higher well-being, which would induce a spurious relationship between the two variables. I also controlled for elapsed time from the beginning of the study, to control for a possible linear increase in variables which could happen as the study days progress and the mere collection of data changes the participant's experience, and it could induce a spurious relationship between two constructs because they would then both simultaneously increase. Although this increased the validity of conclusions, there are other potential within person third variables which could have been confounders in relationships between the variables included in the models. The only true way to eliminate all such possibilities and to, for example, find out whether an increase in in-game need satisfaction really causes an increase in vitality, would be to conduct an experimental study. As explained in the introduction, experimental studies have a disadvantage of being conducted in artificial conditions, so it would probably be best to conduct such study in a natural setting. By following this example, we could assign a group of adolescent gamers

to play a video game or video games that were predetermined to have a high potential for satisfying psychological needs and assign another group to play either no video games or video games with low potential for satisfying psychological needs for a certain period of time, e.g., one or two weeks. Such a study would offer less experimental control than a laboratory study, and it would still be somewhat artificial since participants would be ordered to play certain video games. However, it would offer a greater potential for assessing causality than a regular daily diary study, since it would potentially satisfy all three traditional conditions for drawing a causal conclusion (Shadish et al., 2002): 1. Cause and effect are related, 2. Cause occurs before the effect., and 3. We can rule out plausible alternative explanations for 1 and 2. Of course, we would also have to make sure that factors such as participant expectations (Roque & Boot, 2018) do not influence the results. But if such an experiment would be properly conducted, it would, together with this daily diary study, present quality evidence for the tested relationships.

#### 4.5.1.3 The long-term effects

Besides the issue of causality, another design-related limitation which was already mentioned, is the fact that it is not possible to assess the long-term effects. All effects were assessed at the daily level, and it is not known if they look the same in the long-term. For example, as already discussed, this study found that on days when gamers feel that their real-life needs are frustrated above their daily average, their gaming time falls below their daily average. In other words, they play less on a daily level when their real-life needs are frustrated. It is possible that chronic real-life need frustration would actually lead to more gaming time since in the long run a gamer would try to compensate for this chronically deprived condition by turning to the video game worlds. As mentioned, it could be possible to test this idea by adding measurements after the diary part that are separated by multiple months.

### 4.5.2 Measurement issues

Alongside the design issues, measurement also poses limitations to this study and its conclusions. These limitations are related to the measurement of psychological constructs such as psychological needs and well-being, and to the measurement of objective behaviours such as gaming time and sleep.

#### 4.5.2.1 Issues with measurement of psychological needs

Real-life and in-game psychological needs had relatively low within person reliabilities, ranging from ω=.47 for real-life need satisfaction and ω=.52 for in-game need satisfaction to

ω=.61 for real-life and in-game need frustration. And while Nezlek (2017) stated that within person measures are allowed to have lower reliabilities than those proposed by the conventional benchmarks (e.g., larger than 0.6, Shrout, 1998), and latent variable modelling uses only the variance that is common to the indicators (Sadikaj et al., 2021), it is still valid to ask why these variables have so relatively little variance in common and if it impacts the results. It is interesting to observe that at the between level, although the models were mostly not identified due to too many parameters, the reliabilities were extremely high (e.g., ω=.98), showing that these variables have a lot of variance in common at that level. Although it is common that reliabilities are higher at the between than at the within level, the factor loadings and reliabilities at the within level were still relatively low. In daily diary study by Campbell et al. (2021) where they measured psychological need experiences on adolescents, the within person reliabilities for need satisfaction and frustration were somewhat higher (ω=.66 and ω=.73), although need constructs were measured with four items per need rather than with two items per need as in this study. In this study the measures had to be shorter to accommodate both real-life and in-game needs and this could have lowered the within person reliability of need constructs. Perhaps other items should be chosen for the shortened version of the questionnaires, and it would be good to conduct another validation study to shorten the Basic Psychological Need Satisfaction and Frustration Scale (Chen et al., 2014) for use in within person research. The lower within person reliabilities in this study probably mean that we should interpret results with some caution, although it is possible that with higher reliabilities the relationships between variables could have been even stronger, and not weaker or non-significant. This study was also conducted on adolescents. Although it was preceded by focus groups where it was verified if adolescents understand the items, and many other studies measuring psychological needs were conducted on adolescents, it is still somewhat questionable if adolescents understand these items fully. Perhaps future studies could provide a more detailed investigation into how adolescents understand psychological needs.

#### 4.5.2.2 Issues with measurement of objective behaviours

Objective behaviours, as all the other constructs in this study, were measured via self-report. As already mentioned, this introduces the potential issue of common method bias (Gabriel et al., 2018), but there is also a problem of capturing the true behaviour. Although a great improvement has been made in this study by measuring gaming time daily in four blocks of

time, rather than as a global assessment over a longer time period, it is still possible that these daily assessments diverge from the actual playing time. Unfortunately, since no daily diary studies have been conducted on gamers which would compare the daily diary data with objective estimates of use, we do not know how large this potential discrepancy is. A study by Johannes et al. (2021) showed that, when asked a question about their average daily playing time of a certain video games during the past two weeks, participants overestimate it on average by 0.5 to 1.6 hours. An experience sampling study by Deng et al. (2019) has shown that when asked about their smartphone use in the past hour, participants overestimate it on average by 23 minutes. Although smartphone use is probably harder to assess than gaming time, because the smartphone can be picked up and left many times even during a short period of time whereas gaming is a more continuous activity, it is possible that the participants in this study overestimated their gaming time as well. However, the fact that this study found a lack of connection between gaming time and well-being largely corresponds to what was obtained in the study by Vuorre et al. (2022), where gaming time was measured objectively. A possible overestimation of the gaming time is not so important if the relationships of gaming time with other variables were not distorted. Also, unlike the Johannes et al. (2021) and Vourre et al. (2022) studies, in this study participants reported gaming time for all the games that they played on a given day. As already elaborated in the introduction, this is not possible when data from manufacturers are obtained, since they can only give data for the game that they produced, and this cannot be linked to other games that a player played during the week. Perhaps there are other means that could have been used to measure gaming time more precisely. As elaborated in the introduction, use of tracking apps is not an optimal solution because of ethical concerns and because adolescents may share the computer with other household members. They may also play on a device other than a computer. Using Steam data is not optimal either because at least two weeks of gameplay are needed, and technical difficulties may arise. Another possibility is to try to make the daily diary measurement of gaming time as accurate as possible. I noticed in the raw data that some participants in this study used very precise estimates of gaming time, for example 1 hour and 37 minutes. It is possible that they used stopwatches to record their gaming time, and this could be suggested to all participants in a study. The downside of this approach is that an effort like this to measure one's gaming time could influence the gaming time itself in a natural setting. For example, the participants could realize that a gaming session is already too long or that they have in fact not been playing for long. Finally, if data are obtained from gaming companies, this may be valid if these are games such as World of Warcraft, where players are devoted to a single game. For example, Billieux et al.

(2013) collected objective data of gaming progression of World of Warcraft players. However, in this study most adolescent gamers did not play World of Warcraft and they played a wide variety of different games. In any case, currently there is no perfect solution for measuring gaming time, and future studies should attempt to develop a viable strategy that would enable measuring objective gaming time as accurately as possible, be it through tracking apps or through other means.

Besides gaming time, sleep is also a behaviour that can be objectively measured. In this study, both sleep quantity and quality were self-reported. As elaborated in the introduction, polysomnography is considered to be the "gold standard" in sleep measurement, actigraphy, which involves measuring sleep via a wristwatch device is an alternative that can be used in diary studies, and self-report is a third option. In a recent study, Lehrer et al. (2022) compared polysomnography, actigraphy and daily diary self-report on a sample of middle-aged women and found that daily diary self-reports overestimated total sleep time by 12.6 minutes compared to actigraphy and by 21.2 minutes compared to polysomnography. Daily diaries were sizeably worse in identifying clinically significant sleep disturbances, especially time spent awake after sleep onset. In an older study conducted on children and adolescents, Tremaine et al. (2010) have found that daily diaries overestimated daily sleep time of adolescents by an hour when compared to actigraphy (M=7.84 hours per night vs. M=6.74 hours per night). In a study by Campbell et al. (2021), it was found that when sleep quantity was measured by actigraphy, its relations to psychological need frustration where somewhat different that when sleep quantity was measured via self-report. However, in a study by Yap et al. (2020), the relationships between stress and sleep were actually similar for actigraphy and self-reported sleep. Thus, while self-report probably overestimates sleeping times, it is not clear if and in which measure it distorts the relationship of sleep with other variables. Most importantly, my study had budget and practical constraints, and polysomnography or actigraphy could not be used. As mentioned in the introduction, polysomnography is very expensive and logistically difficult to use, since these devices are not cheap and researchers must either organize measurements at their facility and participants must sleep there or they must visit each participant every day of the study to apply electrodes and calibrate monitors (Lehrer et al., 2022). Actigraphy is also expensive and requires logistical coordination, since every participant must get their actigraphy device (usually a watch) and wear it during the entire duration of the study. These methods were therefore not possible to implement in this study, especially since the study did not have enough budget and its focus was not exclusively on sleep. Moreover, participants were contacted

online, and they were spread across entire Croatia, which had a benefit of creating a heterogeneous sample, but it would not be easy to deliver the devices to the participants and get them back at the end of the study. Furthermore, actigraphy can only measure sleep quantity, and sleep quality still has to be measured with self-report. The measurement of sleep in this study, particularly of sleep quantity, was not perfect and this has to be taken into account when discussing its implications. However, it was more accurate than in any study until now that considered the relationship between gaming time and sleep since none of the studies even used a daily diary design.

Notwithstanding the stated limitations regarding the still present retrospective bias, causal conclusions, measurement, and the long-term effects, this is still a very strong study. It focused on a specific sample of adolescents who regularly play video games, it focused on processes that happen on a daily level and it enabled the assessment of within person effects in the natural environment of these gamers. It also made effort to control the relevant variables in predicting outcomes. These features differentiate this study from the previous work.

#### 4.5.2.3 Issues with pre-registration, study power and generalizability

The final limitations concern pre-registration, study power and generalizability. This study was not pre-registered on a platform such as Open Science Framework (OSF; Foster & Deardorff, 2017) but a study design including introduction, methods, aims and hypotheses was approved by the dissertation committee before ethical approval was sought for and before the data collection commenced. This bears no substantial differences to a procedure of pre-registration on OSF, although actual pre-registration would have made the entire process more transparent to a wider scientific community. Power calculations were not carried out to plan the sample size, since they are rather complicated for these types of models and require defining many parameters that are not easy to estimate before the data are collected. The sample size and the number of study days were instead determined by taking into account the previously conducted diary study on gamers by Allen (2020), diary studies on adolescents conducted within the SDT framework (e.g., Laporte et al., 2021) and general recommendations (Gabriel et al., 2018). Since the focus of this study was on within-person relationships, whose power corresponds to the number of participants times the number of study days (Gabriel et al., 2018) it is reasonable to assume that there was mostly enough power to capture the relevant effects. Finally, this study used a convenience sample, but it was a diverse sample of gamers from all parts of Croatia and from fairly different socioeconomic backgrounds, who played video games

intensively (on average 4 hours and 7 minutes per day) and played different kinds of video games. The results still may not generalize to all adolescent gamers, especially since some gamers were potentially left out because Steam gift cards were awarded for participation in the study. Since Steam is the most popular online platform where one can download and play both online and offline PC digital games (Baumman et al., 2018), gamers who primarily play on consoles may have been left out, and this is perhaps why this sample included only 17% of console gamers. Alternatively, it is possible that more "serious gamers" play on PCs, as it was noticed in a previously conducted qualitative study (Razum & Huić, 2023), and that console gamers were a minority within the sample because they play less regularly and because of that they did not apply for this study. Primarily mobile gamers were even more rare in the sample, which may be even more related to the fact that these gamers are not as invested in gaming as the PC gamers. According to data cited in the introduction, adolescent mobile gamers spend considerably less daily time playing than PC gamers (Rideout, 2015; Rideout & Robb, 2019). Although different kinds of games can be played on mobile devices, this is mostly a platform for casual games, and these games usually do not involve passionate and intensive engagement (Chess & Paul, 2019). The sample was also predominately male, but this is in accordance with previous studies that have showed that adolescent gamers who play more intensively are mostly boys (e.g., Colder-Carras & Kardefelt-Winther, 2018; Razum & Huić, 2023), and the aim of this study was not to explore whether the effects differ according to gender. Gender differences could be considered in future studies, which should then aim to recruit more girls. Socioeconomic status may play a moderating role in the relationships between variables as well. For example, a study by George et al. (2020) has found that adolescents from persistently disadvantaged socio-economic backgrounds who have a social media account have higher psychological distress than adolescents from persistently disadvantaged backgrounds who don't have a social media account, while social media account ownership and psychological distress are not related in adolescents from non-disadvantaged and intermittently disadvantaged backgrounds. Analogous hypotheses could not be tested in this study, as this would require a larger sample which would have to be more heterogenous across socio-economic status. Namely, in this study there were very few participants who reported low socioeconomic status. The study was conducted in Croatia, and results may be different in countries with different cultural pressures surrounding adolescents (Colder-Carras, 2021), such as certain Asian countries, e.g., Korea, Japan, and China. Finally, this study was conducted on highly engaged, but healthy, adolescent gamers. The studied processes and relationships may be different in problematic gamers. It would be worthwhile to investigate whether, for example, problematic

gamers also benefit from in-game need satisfaction and do they also play less videogames as a response to real-life need frustration.

### 4.6 Theoretical and practical implications of the study results

Because adolescents spend so much time playing video games, the impact of video games is relevant, both from scientific and a public policy perspective. This study was the first study to investigate motivational antecedents and consequences of video gaming while using the SDT approach that was both conducted on adolescents and used the daily diary methodology. From a theoretical side, this study used the framework of Self Determination theory (Ryan & Deci, 2017) and tested the relationship between need-based experiences and gaming time, well-being and sleep, and between gaming time and well-being and sleep. It did so while taking into account real-life and in-game need experiences alongside gaming time within the same model, so that the contribution of e.g., in-game need satisfaction to well-being can be assessed as an incremental contribution over real-life need satisfaction and gaming time. From a methodological side, the daily diary methodology allowed to reduce the retrospective bias, namely, to provide a more precise estimate of the used constructs and measures. It allowed to isolate and investigate within person relationships, which in this case deal with the co-occurrence of the daily changes in the constructs, use person as their own control and are more likely to capture the causal lag through which these processes truly operate. From a measurement perspective, gaming time and sleep were measured with as little bias as possible for self-report measurement. Moreover, well-being was measured through different indicators, which allowed a fine-grained analysis of how gaming time and need-based experiences affected it.

The results show that the daily real-life need satisfaction and frustration are key in explaining the daily well-being of adolescents. Daily real-life need satisfaction fosters daily positive affect and daily vitality and lowers daily negative affect, and daily real-life need frustration lowers daily positive affect and vitality and contributes to experienced headaches. Video games offer a contribution to well-being over need-based experiences in real life and this contribution is mostly provided through in-game need satisfaction, and somewhat through in-game need frustration. This study outlined that the positive contribution of daily in-game need satisfaction to daily well-being of adolescents is not trivial, but it is limited to improving daily vitality and to experiencing more positive consequences of video games. The negative contribution of in-

game need frustration is limited to experiencing negative consequences of video games, but the mechanism through which this unfolds is not clear. Gaming time is mostly irrelevant, except for a small connection with positive consequences of video games and slightly negative effects of gaming after midnight to subjective sleep. Also, it seems that, at least on a daily level, adolescent gamers do not compensate for real-life need frustration with gaming, but on the contrary, they play less when their real-life needs are frustrated.

From a practical perspective, to do psychologically well on a daily level, adolescent gamers should, first and foremost, satisfy and not frustrate their psychological needs in real life, and it helps if they satisfy and not frustrate their needs within video games. The focus should be moved from gaming time and placed on need-based experiences as they are much more important in explaining the daily well-being of adolescent gamers. This means that public policies such as the Chinese restriction of gaming time of minors to only three hours per week (Colder Carras et al., 2021) are not only not useful, but also harmful to adolescents. They deny them the opportunity to experience in-game need satisfaction, which was found in this study to be related to experiencing more daily vitality, or in other words energy and enthusiasm, and to experiencing more daily positive consequences of video games, such as learning something new and socializing with friends. The public policies aimed at improving the well-being of adolescent gamers should focus on need-based experiences, firstly in real life, but also in video games. Previous research has established three parental strategies that are crucial in facilitating need satisfaction in children and adolescents (Grolnick & Lerner, 2023), namely autonomy support, structure, and involvement. Autonomy support involves understanding and having in mind the perspective and goals of children. It does not mean that parents should fulfil every wish of their child, but they should support children's initiatives, provide choices, give children input and work together with them on solving problems. They should show empathy when a child cannot directly get what they desire (Grolnick & Lerner, 2023). Involvement means providing resources to children, which involves material resources such as books and immaterial resources such as time spent with them, learning about them and providing love and affection. Structure means giving clear guidelines and expectations (Grolnick & Lerner, 2023). When parents use these strategies in raising them, children feel autonomous, competent and related to important others and they are more likely to develop intrinsic motivation for important activities (Grolnick & Lerner, 2023). Interventions could be aimed at teaching the parents of adolescent gamers about these strategies and motivating them to use them. Needs satisfaction can also be fostered in the context of schools, where teachers can be autonomy

supportive by appreciating the perspective of students, responding to their initiative, and encouraging them to take ownership of their work (Ryan, 2023). Finally, gamers themselves could participate in trainings on how to foster real-life need satisfaction, and deal with real-life need frustration on one hand, and on the other hand, how to better pursue those gaming experiences that satisfy their psychological needs and how to recognize and deal with need frustration while gaming. The concerns over the influences of gaming on sleep seem to be overblown, but gaming after midnight should be done in moderation.

## 5. CONCLUSION

This study sought to examine the relations between basic psychological needs and gaming time and between basic psychological needs, gaming time and well-being and sleep, all on the within person level. It was the first study that used real-life and in-game psychological needs in one model alongside gaming time and that was conducted by using the daily diary methodology on adolescents. Its first main finding was that daily real-life psychological need frustration was negatively related to daily gaming time, which was contrary to the hypothesized relationship. Although cross-sectional studies show that those who have more need frustration in their lives play more video games, it was shown that this is not the case on the daily level, and that gamers tend to reduce their playing when they experience a need frustrating day. This finding provided an insight into daily coping mechanisms of adolescent gamers, but new studies are needed to investigate coping in the long run. The daily well-being of gamers was mostly defined by their real-life need satisfaction and need frustration. In-game need satisfaction and frustration contributed less to well-being than hypothesized. In-game need satisfaction did contribute to daily vitality over and above the real-life need satisfaction and to experiencing self-perceived positive consequences of gaming on that day (i.e., learning something new, socializing). In-game need frustration was related to negative consequences of gaming on that day (i.e., missing out on an important activity because of gaming), but this may be due to the real-life need frustration. Contrary to the hypotheses, need-based experiences did not contribute to sleep quality and quantity and gaming time did not contribute to neither well-being nor sleep. Only gaming after midnight was weakly negatively related to sleep quality.

All in all, daily need satisfaction and frustration were a key determinant of adolescent gamers' daily well-being, and in-game need satisfaction had some additional contribution, most notably to daily vitality, i.e., the sense of energy and aliveness. At the same time, gaming time was not related to neither well-being nor sleep. This means that no matter how much they play video games, adolescent gamers who satisfy and not frustrate their real-life psychological needs will experience a sense of daily well-being. These adolescents will then probably successfully integrate gaming into their daily lives and possibly experience benefits to their daily vitality from satisfying their in-game needs. Concerns about gaming time affecting adolescent well-being and sleep are misplaced as we should really be focusing on fostering their positive need experiences, both in real life and in video games.

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## 7. APPENDIX A

Table 1 Detail demographic participant characteristics

| Participant characteristic | | Percentage (% out of n= 125) |
|---|---|---|
| High school type | Three-year trade school | 8.8 |
| | Four-year trade school | 68.0 |
| | General gymnasium | 9.6 |
| | Natural sciences and mathematics gymnasium | 7.2 |
| | Linguistic or classic gymnasium | 6.4 |
| Locality size | Village | 26.4 |
| | Smaller town up to 10.000 inhabitants | 13.6 |
| | City from 10.000 to 100.000 inhabitants | 25.6 |
| | City from 100.000 to 500.000 inhabitants | 8.8 |
| | The city of Zagreb | 25.6 |
| Counties within Croatia (most common) | City of Zagreb county | 22.8 |
| | Zagreb county | 14.6 |
| | Vukovar-Srijem county | 9.8 |
| | Bjelovar-Bilogora county | 7.3 |
| | Brod-Posavina county | 6.5 |
| | Međimurje county | 5.7 |
| | Split-Dalmatia county | 5.7 |
| Family income | Under average | 6.4 |
| | Average | 64.0 |
| | Above average | 24.8 |
| | Highly above average | 4.8 |
| How does my family live with their income? | It's very hard for us to get by with our income | 0.8 |

| | | |
|---|---|---|
| | It's hard for us to get by with our income | 12.0 |
| | We get by with our income | 56.0 |
| | We live well with our income | 31.2 |
| Father's highest attained level of education | Elementary school | 3.2 |
| | Three-year high school | 16.8 |
| | Four-year high school | 51.2 |
| | College | 7.2 |
| | University (M.A.) | 12.0 |
| | Post-graduate | 4.0 |
| Mother's highest attained level of education | Elementary school | 4.8 |
| | Three-year high school | 16.8 |
| | Four-year high school | 48.8 |
| | College | 6.4 |
| | University (M.A.) | 13.6 |
| | Post-graduate | 5.6 |
| Religiosity | I am a complete believer | 17.6 |
| | I am a believer, but I don't accept all the teachings | 18.4 |
| | I am not sure | 28.8 |
| | I am indifferent toward religion | 13.6 |
| | I am not religious | 20.8 |

## 8.. APPENDIX B

Table 1 Moderator effects concerning the relationship between gaming time and positive consequences of video games

| Moderator | One-tailed significance | 95% credibility interval of the effect | Model |
|---|---|---|---|
| Gaming disorder | .354/ .282 | [-.952 - .655] / [-1.158 - .529] | 1e/1f |
| Self-control | .140 / .087 | [-.387 – 1.049] / [-.252 – 1.154] | 1e/1f |
| Harmonious passion | .475 / .467 | [-.399 - .450] / [-.429 - .439] | 1e/1f |
| Obsessive passion | .337 / .241 | [-.383 - .584]/ [-.329 - .696] | 1e/1f |
| Game genres: MOBA | .158 / .202 | [-.674 - .210] / [-.752 - .261] | 1e/1f |
| Sport games | .379 / .304 | [-.350 - .484] / [-.324 - .553] | 1e/1f |
| Action and adventure games | .232 / .326 | [-.242 - .588] / [-.280 - .455] | 1e/1f |
| Battle royale games | 0.154 / .218 | [-.178 - .627] / [-.253 - .548] | 1e/1f |
| Sandbox games | .450 / .477 | [-.407 - .324] / [-.366 - .366] | 1e/1f |

*Note*: Significance and credibility intervals for models 1e and 1f are separated by a dash. Model 1e includes in-game and real-life psychological need satisfaction and gaming time as predictors, whereas model 1f includes in-game and real-life psychological need frustration and gaming time. Only credibility intervals for standardized effects are shown.

Table 2 Moderator effects concerning the relationship between gaming time and negative consequences of video games

| Moderator | One-tailed significance | 95% credibility interval of the effect | Model |
|---|---|---|---|
| Gaming disorder | .350 / .311 | [-1.077 - .755] / [-1.099 - .717] | 1e/1f |
| Self-control | .281 / .249 | [-.885 – 1.010] / [-.870 – 1.083] | 1e/1f |
| Harmonious passion | .145 / .210 | [-.767 - .274] / [-.823 - .399] | 1e/1f |
| Obsessive passion | .079 / .077 | [-.204 - .952]/ [-.160 - .986] | 1e/1f |
| Game genres MOBA | .416 / .277 | [-.550 - .657] / [-.408 - .705] | 1e/1f |
| Sport games | .297 / .330 | [-.724 - .436] / [-.649 - .560] | 1e/1f |
| Action and adventure games | .174 / .184 | [-.663 - .255] / [-.712 - .250] | 1e/1f |

| | | | |
|---|---|---|---|
| Battle royale games | .448 / .500 | [-.553 - .611] / [-.524 - .579] | 1e/1f |
| Sandbox games | .471 / .153 | [-.464 -.486] / [-.247 - .645] | 1e/1f |

*Note*: Significance and credibility intervals for models 1e and 1f are separated by a dash. Model 1e includes in-game and real-life psychological need satisfaction and gaming time as predictors, whereas model 1f includes in-game and real-life psychological need frustration and gaming time. Only credibility intervals for standardized effects are shown.

Table 3 Moderator effects concerning the relationship between gaming time and sleep quantity

| Moderator | One-tailed significance | 95% credibility interval of the effect | Model |
|---|---|---|---|
| Gaming disorder | .112 / .048 | [-1.212 - .381] / [-1.433 - .107] | 2a/2b |
| Self-control | .332 / .232 | [-.833 – 1.000] / [-.623 – 1.001] | 2a/2b |
| Harmonious passion | .305 / .420 | [-.581 - .395] / [-.558 - .490] | 2a/2b |
| Obsessive passion | .022 / .011 | [.000 – 1.012] / [.001 – 1.068] | 2a/2b |
| Game genres: MOBA | .179 / .191 | [-.658 - .297] / [-.641 - .292] | 2a/2b |
| Sport games | .178 / .237 | [-.812 - .324] / [-.829 - .454] | 2a/2b |
| Action and adventure games | .249 / .248 | [-.657 - .333] / [-.618 - .317] | 2a/2b |
| Battle royale games | .138 / .151 | [-.784 - .231] / [-.677 - .250] | 2a/2b |
| Sandbox games | .324 / .261 | [-.337 - .476] / [-.285 - .516] | 2a/2b |

*Note*: Significance and credibility intervals for models 1e and 1f are separated by a dash. Model 2a includes in-game and real-life psychological need satisfaction and gaming time as predictors, whereas model 2b includes in-game and real-life psychological need frustration and gaming time. Only credibility intervals for standardized effects are shown.

Table 4. Moderator effects concerning the relationship between gaming time and sleep quality

| Moderator | One-tailed significance | 95% credibility interval of the effect | Model |
|---|---|---|---|
| Gaming disorder | .289 / .226 | [-1.176 - .695] / [-1.332 - .583] | 2a/2b |
| Self-control | .374 / .400 | [-1.000 - .877] / [-1.000 – 1.000] | 2a/2b |
| Harmonious passion | .236 / .361 | [-.657 - .314] / [-.657 - .412] | 2a/2b |
| Obsessive passion | .036 / .050 | [-.041 - 1.069] / [-.142 – 1.056] | 2a/2b |
| Game genres: MOBA | .433 / .345 | [-.529 - .621] / [-.479 - .700] | 2a/2b |

| | | | |
|---|---|---|---|
| Sport games | .419 / .315 | [-.609 - .707] / [-.510 - .804] | 2a/2b |
| Action and adventure games | .146 / .154 | [-.755 - .249] / [-.700 - .271] | 2a/2b |
| Battle royale games | .461 / .439 | [-.697 - .570] / [-.517 - .549] | 2a/2b |
| Sandbox games | .455 / .450 | [-.557 - .479] / [-.476 - .498] | 2a/2b |

*Note*: Significance and credibility intervals for models 1e and 1f are separated by a dash. Model 2a includes in-game and real-life psychological need satisfaction and gaming time as predictors, whereas model 2b includes in-game and real-life psychological need frustration and gaming time. Only credibility intervals for standardized effects are shown.

## 9. CURRICULUM VITAE

Josip Razum was born in Zagreb, Croatia where he finished his B.A. and M.A. in psychology at the Faculty of Humanities and Social Sciences.

During his studies, he was a student demonstrator, and he was active in the student association "STUP", where he was the president in 2015/2016. He took part in a summer internship at the University of Cambridge in 2015 and did a six-month Erasmus+ exchange stay at the University of Ulm in Germany in 2016. He received the "City of Zagreb" scholarship. He was later also active in the European Federation of Psychology Students Associations (EFPSA), where he led the "Social impact" team, which was responsible for the European-wide mental health education campaign "Mind the mind".

In 2018 he worked for six months for the behavioural consulting company "Behave" and from 2019 until now he works at the Ivo Pilar Institute of Social Sciences. He enrolled into the PhD program at the Faculty of Humanities and Social Sciences, University of Zagreb, in 2019. In 2023, he did a three-month research stay at the Laura Bringmann's intensive longitudinal data lab at the University of Groningen.

He published four first authored research papers in reputable publications, among which were the Clinical Psychology Review and Behaviour and Information Technology. He published several other papers where he was one of the coauthors. He reviewed several papers for journals such as the Scandinavian Journal of Psychology. He presented his work at multiple conferences, both domestic and international. He attended multiple statistical summer schools and workshops. He mostly works in R and Mplus. His research interests include research methods and media use, psychopathology, and psychotherapy research. He is a member of the International Society for the Study of Behavioral Addictions and the Society of Ambulatory Assessment. In his free time, he likes to read, write, play basketball, and spend time with dear people.

### 9.1 Scientific publications

Razum, J. & Huić, A. (2023). Understanding highly engaged adolescent gamers: Integration of gaming into daily life and motivation to play video games. *Behaviour and Information Technology*. https://doi.org/10.1080/0144929X.2023.2254856

Razum, J., Baumgartner, B., & Glavak Tkalić, R. (2023). Psychometric validity and the appropriateness of tolerance as a criterion for internet gaming disorder: A systematic

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