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Psychofizjologiczny Model Wyzwania i Zagrożenia w E-sporcie

Psychophysiological Model of Challenge and Threat in Esports

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SPIS TREŚCI

Lista Publikacji

Podstawą niniejszej pracy doktorskiej, są trzy artykuły opublikowane w czasopismach recenzowanych:

Behnke, M., Kaczmarek, L.D. (2018). Successful performance and cardiovascular markers of challenge and threat: a meta-analysis. *International Journal of Psychophysiology, 130,* 73-79. https://doi.org/10.1016/j.ijpsycho.2018.04.007

Behnke, M., Kosakowski, M., Kaczmarek L.D. (2020). Social challenge and threat predict performance and cardiovascular responses during competitive video gaming, *Psychology of Sport and Exercise, 46*, 101548. https://doi.org/10.1016/j.psychsport.2019.101584

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Streszczenie

Ważną rolę w wyjaśnieniu poziomu wykonania realizowanych zadań pełni ewaluacja sytuacji zadaniowej oraz występujące w jej trakcie zmiany fizjologiczne. Osoby, które oceniają swoje umiejętności za przewyższające wymagania niezbędne do realizacji zadania, efektywnie aktywują zasoby fizjologiczne (stan wyzwania) i dzięki temu osiągają lepsze wyniki. Natomiast w sytuacji ocenianej jako zagrożenie, następują zmiany fizjologiczne, ukierunkowane na minimalizowanie strat, które nie tylko utrudniają realizację celu, ale mogę długofalowo szkodzić zdrowiu. Opierając się na bio-psycho-społecznym modelu wyzwania i zagrożenia, oraz motywacyjno-dymensjonalym modelu afektu, zbadano nowe czynniki emocjonalne, które mogą pozytywnie wpływać na poziom wykonania w trakcie występu e-sportowego. W badaniu pierwszym, dzięki, przeprowadzonej meta-analizie, oszacowano średnią wielkość efektu dla związku pomiędzy skutecznością występu a reaktywnością parametrów układu krążenia – objętości minutowej serca oraz oporu obwodowego. Wykazano, że osiąganiu lepszych wyników sprzyja wzrost objętości minutowej serca oraz spadek oporu obwodowego. W badaniu drugim, w eksperymencie laboratoryjnym w formie turnieju e-sportowego wykazano, że gracze z większym doświadczeniem w grze, częściej oceniali sytuację występu w kategoriach wyzwania, co w rezultacie przenosiło się na ich większe zaangażowanie fizjologiczne i lepsze rezultaty w trakcie gry. Wyniki badania 1 i 2 dostarczyły wsparcia dla modelu bio-psycho-społecznego w wyjaśnianiu poziomu wykonania. W badaniu trzecim, wykazano, że wzbudzone pozytywne emocje, sprzyjają osiąganiu lepszych wyników w grze, dzięki zwiększeniu motywacji do dążenia. Ponadto gracze o silnym przekonaniu na temat swoich możliwości i angażujący więcej zasobów fizjologicznych w trakcie gry (stan wyzwania) osiągali lepsze wyniki. Podsumowując, projekt ten przyczynił się do rozwoju wiedzy w obszarze psychofizjologii (replikacja zasadniczych założeń bio-psycho-społecznego modelu wyzwania i zagrożenia), psychologii emocji (nowe dowody na rozbieżność funkcji emocji

o wysokiej i niskiej motywacji) oraz psychologii sportu (rozwój metod możliwych do wykorzystania w przygotowaniach graczy).

Słowa kluczowe: e-sport, wyzwanie, zagrożenie, emocje o silnej motywacji do dążenia, reaktywność sercowo-naczyniowa.

Abstract

Evaluations and their physiological consequences play an important role in determining performance outcomes. Individuals evaluating their resources as exceeding the situational demands required for performance activate additional physiological resources (challenge state) and, in turn, perform better. On the other hand, individuals evaluating their resources as insufficient to cope with the situational demands required for performance activate maladaptive physiological response (threat state), which not only hinder the performance outcomes, but also can damage health in the long term. Based on biopsychosocial model of challenge and threat, and motivational dimensional model of affect, we investigated new emotional factors that could facilitate gaming performance. In Study 1, we used meta-analytic approach to determine the mean effect size for the association between performance level and cardiovascular reactivity measures - cardiac output and total peripheral resistance. We found that increase of cardiac output and decrease of total peripheral resistance had small, but facilitative effects on performance outcomes. In Study 2, in a laboratory experiment in the form of an e-sport tournament, we found that gamers with more gaming experience, were more likely to evaluate the performance situation as a challenge, which resulted in their greater physiological engagement and better performance outcomes. The results of Study 1 and Study 2 provided support for the biopsychosocial model of challenge and threat in explaining performance outcomes. In Study 3, we found that elicited pleasant emotions lead to better gaming performance, by increasing approach-motivation. Furthermore, gamers with higher levels of cognitive and cardiovascular challenge achieved higher scores. In conclusion, the project has contributed to the development of knowledge in the field of psychophysiology (replication of the basic assumptions of the biopsychosocial model of challenge and threat), affective science (new evidence for the differences between high- and low-approach emotions), and sports psychology (development of methods that can be used in the preparation of players).

Keywords: esport, challenge, threat, high-approach emotions, cardiovascular reactivity.

Wprowadzenie

Przedmiotem projektu było przetestowanie psychofizjologicznego modelu opisującego zjawiska motywacyjne i afektywne oraz ich następstwa fizjologiczne i behawioralne w trakcie występów e-sportowych. Podstawę teoretyczną stanowią modele opisujące nowe zjawiska motywacyjno-fizjologiczne (Blascovich, 2008) i afektywne (Gable, Harmon-Jones, 2010). Z kolei zamienną zależną stanowił poziom wykonania różnych zadań (badanie 1) ze szczególnym uwzględnieniem występów e-sportowych (badanie 2 i 3).

Niniejsza praca doktorska składa się z trzech części. W pierwszej został przedstawiony aktualny stan wiedzy. Na początku zostały przedstawione podstawy teoretyczne pracy, a następnie przedstawiona została problematyka związana z grami wideo i e-sportem. W drugiej części pracy przedstawiony został projekt badań własnych, składający się z krótkiego wprowadzenia do celów badań oraz cyklu trzech spójnych tematycznie artykułów, będących podstawą niniejszej pracy. W trzeciej części znajduje się podsumowanie przeprowadzonych badań.

Aktualny Stan Wiedzy

Wyzwanie i Zagrożenie

Podstawą teoretyczną pracy doktorskiej jest bio-psycho-społeczny model wyzwania i zagrożenia (Blascovich, 2008; Seery, 2013). Wybrany model teoretyczny integruje w swoim podejściu analizę procesów motywacyjnych na poziomach – biologicznym, psychologicznym i społecznym. Na poziomie biologicznym model ten skupia się na badaniu zależności pomiędzy autonomicznym układem nerwowym, układem hormonalnym oraz układem krążenia. Psychologiczna analiza dotyczy czynników poznawczych oraz afektywnych związanych z sytuacją występu. Natomiast na poziomie społecznym integruje zagadnienia interpersonalne oraz wpływy środowiska. Bio-psycho-społeczny model wyzwania i zagrożenia (Blascovich, 2008) zakłada połączenie między procesami psychologicznymi i fizjologicznymi w organizmie w trakcie występów, wskazując na warunki, w których procesy poznawcze inicjują zmiany fizjologiczne, które usprawniają bądź utrudniają aktywność zadaniową (Seery, 2013).

Model bio-psycho-społeczny wyzwania i zagrożenia, dotyczy sytuacji, w których jednostka posiada wewnętrznie istotny cel, oraz podejmuje aktywne działania, by go osiągnąć. Jednostka angażując swoje zasoby, dąży do sprostania wymaganiom sytuacyjnym. Sytuacja opisana wcześniej definiowana jest jako zmotywowany występ, a jej przykładami są udział w zawodach sportowych, występ muzyczny, egzamin na studiach czy prezentacja biznesowa. Model bio-psycho-społeczny zakłada, że kontekst zmotywowanego występu, prowadzi do stanu zaangażowania w wykonywane zadanie, które wynika ze spostrzeganej istotności celu.

Ocena Sytuacji jako Wyzwania i Zagrożenia

Przystępując do realizacji zadania, jednostka ocenia swoje zasoby i zestawia je z wymaganiami sytuacyjnymi. Jeśli dana osoba ocenia swoje zasoby jako wystarczające lub przewyższające wymagania związane z osiągnięciem celu, to odczuwany pozytywny stan motywacyjny jest określany mianem wyzwania. Natomiast, gdy osobiste zasoby oceniane są jako nie wystarczające w stosunku do wymagań, wtedy negatywnie nacechowany stan motywacyjny określany jest jako zagrożenie (Blascovich, 2008). Do wymagań sytuacyjnych zalicza się m.in. ryzyko niepowodzenia, niepewność warunków realizacji zadania, poziom trudności zadania, natomiast do osobistych zasobów można zaliczyć posiadane przez osobę umiejętności istotne z punktu widzenia realizacji zadania, wiedzę, postawy wobec zadania, czy dostępne wsparcie społeczne (Blascovich i in., 2003).

Model bio-psycho-społeczny wyzwania i zagrożenia wykorzystuje elementy modelu stresu i radzenia sobie ze stresem Richarda Lazarusa (Lazarus, 1998, s. 18-23). Ocena poznawcza (*cognitive appraisal*), jest definiowana jako proces umysłowy, w wyniku, którego podmiot określa relację między sobą a otoczeniem i ustosunkowuje się do tej relacji (Lazarus, 1998). Według modelu Lazarusa różnice w ewaluacji sytuacji zadaniowej wyjaśniają, dlaczego ludzie różnie podchodzą do sytuacji zadaniowych i osiągają zróżnicowane efekty działania. Ocena poznawcza przebiega w dwóch etapach: pierwotnym i wtórnym. Ocena pierwotna (*primary appraisal*) ma charakter motywacyjny i dotyczy siły związku danej zmiany w otoczeniu z dobrostanem jednostki. Jeżeli zmiana nie wiąże się w sposób istotny z dobrostanem jednostki, to nie powoduje ona reakcji motywacyjnej i kolejne etapy oceny poznawczej nie następują. Jeśli jednak dana zmiana jest zgodna z celami jednostki dochodzi do oceny wtórnej (*secondary appraisal*), gdzie następuje oszacowanie poziomu zasobów jednostki i strategii radzenia sobie w sytuacji zadaniowej.

Zgodnie z modelami teoretycznymi, ocena występu zgodna ze stanem wyzwania (zasoby wyższe od wymagań) usprawnia działanie osób w sytuacji zadaniowej (Blascovich, 2008). Usprawniającą funkcję stanu wyzwania w różnych kontekstach wykazano w szeregu badań, gdzie zmotywowany występ dotyczył m.in.: egzaminu na studiach (Seery i in., 2010), testów poznawczych (Mendes i in., 2008; Turner i in., 2012), testów logicznych (Chalabaev i in., 2009), testów sportowych (Blascovich i in., 2004, Meijen i in., 2014, Moore i in., 2012, Moore i in., 2013, Turner i in., 2012), czy symulacji operacji chirurgicznej (Vine i in., 2013).

Reakcje Układu Krążenia Związane z Oceną Sytuacji jako Wyzwania i Zagrożenia

Model bio-psycho-społeczny opiera się na pracach dotyczących wytrzymałości czy też tzw. twardości fizjologicznej (*physiological toughness*, Dienstbier, 1989), które uwzględniały relację pomiędzy stanami motywacyjnymi a reakcjami fizjologicznymi u zwierząt. Zakładano, że organizm przygotowuje się do zmotywowanego działania przez mobilizacje osi sympatycznej rdzenia nadnerczy (*sympatheticadrenomedullary axis,* SAM) oraz osi podwzgórze-przysadka-nadnercza (*hypothalamic-pituitary-adrenal axis,* HPA). Zarówno aktywacja osi SAM, jak i osi HPA, powoduje mobilizacje rezerw energetycznych dla potencjalnej aktywności fizycznej. Przy czym aktywacja osi SAM pozwala na krótkotrwałą mobilizację rezerw energetycznych przez uwolnienie adrenaliny, która ma stosunkowo krótki czas uwalniania i czas półtrwania w krwiobiegu (kilka minut). Natomiast aktywacja osi HPA prowadzi do długotrwałej mobilizacji ustroju, przez uwolnienie kortyzolu, który ma wolniejszy czas uwalniania i znacznie dłuższy okres półtrwania, który trwa ponad godzinę. W swoich pracach Dienstbier (1989) opisał połączenie szybkiego rozpoczęcia i zakończenia aktywacji osi SAM bez aktywacja osi HPA jako charakterystyczną "twardość” (*toughness*), która u ludzi miała wiązać się z pozytywnymi wynikami w zadaniach wymagających wysokiej jakości wykonania, stabilności emocjonalnej i brak lęku (np. sytuacja występu sportowego). Zgodnie z modelem, twardość fizjologiczna łączy się z tendencją do odbierania sytuacji jako możliwej do opanowania (Dienstbier, 1989), którą za modelem bio-psycho-społecznym można nazwać wyzwaniem (Blascovich, 2008).

Z perspektywy bio-psycho-społecznego modelu wyzwania i zagrożenia, kluczowe są cztery parametry układu krążenia: częstotliwość skurczów serca (*heart rate*, HR, ilość uderzeń serca w ciągu jednej minuty), okres przedwyrzutowy lewej komory (*pre-ejection period*, PEP, czas w cyklu pracy serca od rozpoczęcia depolaryzacji komór do otwarcia zastawki aortalnej i wyrzucania krwi, podawany w milisekundach), objętość minutowa serca (*cardiac output,* CO, ilość krwi przepompowanej przez serce na minutę, podawana w litrach), całkowity opór obwodowy (*total peripheral resistance*, TPR, wskaźnik zawężania/rozszerzania sieci naczyń krwionośnych).

Model bio-psycho-społeczny zakłada, że różnicowanie pomiędzy stanem wyzwania i zagrożenia jest zasadne w przypadku wysokiego zaangażowania w wykonywane zadanie (Blascovich, 2008). Zaangażowanie doprowadza do podwyższonej aktywacji układu sympatycznego, co prowadzi do zwiększenia częstotliwości skurczów serca oraz skrócenia okresu przedwyrzutowego (Seery, 2011).

Następnie w obliczu oceny sytuacji jako wyzwania następuje uwolnienie adrenaliny do krwiobiegu. Dochodzi do rozszerzenia się tętnic, co obniża całkowity opór obwodowy (Brownley i in., 2000). Skutkuje to również wyższą pojemnością minutową serca (ilością krwi przepompowanej przez serce w ciągu minuty). Z kolei odbiór sytuacji jako zagrożenia aktywuje oś hamującą uwalnianie adrenaliny, a uwalniany jest kortyzol. Tętnice pomimo zwiększonej częstotliwości skurczów serca, zwężają się, co prowadzi do stosunkowo wyższego całkowitego oporu obwodowego i relatywnie niższej pojemności minutowej serca (Seery, 2011). Innymi słowy, podczas sytuacji zadaniowej zarówno w stanie wyzwania jak i zagrożenia, serce bije szybciej i mocniej, w stosunku do stanu spoczynkowego. Podczas wyzwania, mobilizacja ta skutkuje tym, że serce przepompowuje relatywnie więcej krwi przez układ krwionośny, w przeciwieństwie do zagrożenia, gdzie tętnice zwężają się, więc pomimo tego, że serce pracuje tak samo ciężko jak w czasie wyzwania, to relatywnie mniej krwi jest rzeczywiście pompowane przez układ krwionośny. Odpowiedź organizmu zgodna ze wzorcem stanu wyzwania, mobilizuje organizm do sprawniejszego działania, szczególnie fizycznego, gdzie więcej krwi trafia do naczyń włosowatych, co oznacza lepsze zaopatrzenie energetyczne dla komórek ciała.

Wskaźniki związane z zaangażowaniem w zadanie oraz stanami wyzwania i zagrożenia stanowią obiektywną miarę relacji pomiędzy reakcjami fizjologicznymi, a funkcjonowaniem poznawczym, a ich trafność i rzetelność potwierdzają badania korelacyjne i eksperymentalne (m.in., Tomaka i in., 1997, Moore, i in., 2012).

Podsumowując cześć modelu skupiająca się na parametrach układu krążenia, stan wyzwania usprawnia działanie w sytuacji występu, zapewniając odpowiedni fundament fizjologiczny. W stanie wyzwania dochodzi do mobilizacji rezerw energetycznych koniecznych do działania. Jednym z celów naszych badań jest aplikacja modelu bio-psycho-społecznego do specyficznych warunków występu e-sportowego, który mógłby stanowić podstawę do dalszych różnorodnych badań w e-sporcie.

Metody Wzbudzania Stanów Wyzwania i Zagrożenia

W dotychczasowych badaniach nad bio-psycho-społecznym modelem zidentyfikowano wybrane czynniki mające wpływ na wzbudzenie stanu wyzwania i zagrożenia, włączając czynniki intrapersonalne - m.in. stabilność samooceny (Seery i in., 2004), postawę wobec zadania (Blascovich i in., 1993); interpersonalne - m.in.: facylitację społeczną, (Blascovich i in., 1999), porównania społeczne (Mendes i in., 2001); oraz środowiskowe - m.in.: poziom trudności (Fonseca i in., 2014), możliwość zysku/utraty dóbr (Seery i in., 2009).

Do wzbudzenia stanu wyzwania i zagrożenia wykorzystywano dotychczas różnorodne metody, włączając w to instrukcje motywujące przed występem (Moore i in., 2012), mowę wewnętrzną (Hase, Hood i in., 2019), zmianę oceny poznawczej pobudzenia (Sammy i in., 2017), czy też wyobrażenia (Williams et al., 2010). Jedną ze skutecznych metod wzbudzania wyzwania i zagrożenia jest podawanie odpowiednich komunikatów przed wykonaniem zadania (Mendes i in., 2001; Moore i in., 2012; Vine i in., 2013). By wzbudzić stan wyzwania przedstawia się ludziom informację, by myśleli o nadchodzącym występie jak o wyzwaniu - sytuacji, której są w stanie sprostać i osiągnąć upragniony rezultat. Informuje się osoby badane, że badania naukowe dowodzą, że najlepsi sportowcy poprawiają swoje rezultaty w trakcie najważniejszych występów. Zachęca się osoby by przystąpiły do rywalizacji myśląc o sobie jako o zawodniku, który potrafi sprostać wyzwaniu i daje z siebie wszystko. Natomiast stan zagrożenia można wzbudzić, informując osoby o tym, że nadchodzący występ może być dla nich zadaniem trudnym i frustrującym, co może powodować, że nie dadzą rady poprawić swoich wyników w trakcie występu. Wspomina się, że badania naukowe dowodzą, że nawet najlepsi sportowcy nie poprawiają swoich rezultatów w trakcie ważnych występów. Zaznacza się, że nadchodzący występ będzie niezwykle trudny, lecz zawodnicy ci powinni, mimo to, dać z siebie wszystko.

W badaniu drugim właśnie ta metoda została zastosowana do wzbudzenia stanów wyzwania i zagrożenia. Gracze po pierwszej rundzie rywalizacji, otrzymali komunikat zwrotny na temat ich występu. Przez co w drugiej rundzie rywalizacji przystąpili w stanie wyzwania lub zagrożenia, w zależności od otrzymanej informacji zwrotnej. W badaniu trzecim natomiast, wykorzystano nową metodę wzbudzenia stanu wyzwania i zagrożenia, tj. przez wzbudzenie wybranych emocji przed samą rozgrywką.

Emocje i Motywacje Związane z Oceną Sytuacji jako Wyzwania i Zagrożenia

Emocje stanowią wielopoziomowe i obejmujące całe ciało zjawiska, włączając zmiany w obszarze: subiektywnego doświadczania, zachowania, oraz centralnych i obwodowych układów fizjologicznych (Mauss, Robinson, 2009). Sekwencja powstania emocji zaczyna się od sytuacji istotnej z punktu widzenia celów jednostki, np. występu sportowego (Gross, Thompson, 2007). Ponadto emocje powstają w wyniku ciągłego cyklu ich generowania i regulacji, gdzie nie tylko zwrócenie uwagi lub ocena sytuacji wpływa na odpowiedź emocjonalną, ale również owa odpowiedź może wpłynąć ponownie na ewaluację (Gross, 2015). Ma to szczególne znaczenie w przypadku badań eksperymentalnych, gdzie testuje się, jak wzbudzane emocje wpływają na funkcjonowanie osób badanych zarówno w odniesieniu do końcowej odpowiedzi – skuteczności działania w sytuacji zadaniowej, jak i procesów które na nie wpływają – np. oceny zasobów wobec wymagań sytuacyjnych.

Wcześniejsze badania wskazują na powiązania między stanami wyzwania i zagrożenia, a walencją afektu, inaczej mówiąc znakiem emocji na skali pozytywnego i negatywnego afektu. Stan wyzwania był wcześniej łączony z pozytywnymi emocjami (np. Nicholls, Perry, Calmeiro, 2014; Nicholls, Polman, Levy 2012), natomiast stan zagrożenia z emocjami negatywnymi (np. Meijen, i in., 2013; Nicholls, i in., 2014). Dodatkowo stan wyzwania łączony był również z bardziej pozytywną interpretacją występujących negatywnych emocji (Williams, Cumming, Balanos, 2010). Jednakże, nie wszystkie badania zgodnie łączą pozytywne emocje i wyzwania, oraz negatywne emocje i zagrożenia, wskazując na niespójność wyników w tej kwestii (np. Turner, i in., 2012, Turner, i in., 2013; Turner, i in., 2014).

Propozycje teoretyczne (np. Seery, 2013), wskazują na uzupełnienie psychofizjologicznego modelu wyzwania i zagrożenia o tzw. motywacyjny model afektu (Gable, Harmon-Jones, 2010). Zakłada się, że stany wyzwania i zagrożenia powinny być łączone w wymiarem intensywności motywacyjnej emocji, a nie walencji afektu. Wskazuje się, że stan wyzwania powinien być związany z emocjami o wysokim ładunku motywacji do dążenia, natomiast stan zagrożenia z emocjami związanymi z niskim ładunkiem motywacji do dążenia lub motywacją do unikania (Seery, 2013). Motywację do dążenia (lub unikania) definiuje się, jako impuls do dążenia/zaangażowania (lub unikania), podążenia naprzeciw (lub awersji) bez specyfikacji walencji bodźca, wobec którego ów impuls występuje (Harmon-Jones i in., 2013). Motywację do dążenia łączy się z bodźcami związanymi z nagrodami, apetytami, podnietami, natomiast motywacje do unikania z karami, awersją i zagrożeniem. Tradycyjne podejście do emocji, łączące wymiar motywacji do dążenia i unikania z wymiarem walencji (pozytywne i negatywne doświadczenie), zakładało nierozerwalnie powiązanie, pomiędzy tymi wymiarami (motywacją do dążenia z i pozytywnymi odczuciami oraz motywacją do unikania z negatywnymi; Cacioppo, Gardner 1999; Russell, Carroll, 1999). Współczesne badania wskazują jednak na możliwość rozerwania wcześniejszych ustalonych związków.

Zgodnie z motywacyjnym dymensjonalnym modelem afektu (Gable, Harmon-Jones, 2010) emocje podobne do siebie pod względem walencji afektu oraz pobudzenia, mogą się różnić na wymiarze motywacji do dążenia. Niektóre pozytywne bodźce (np. prowadzące do rozbawienia) mogą wywoływać pozytywny afekt (tj. przyjemne doświadczenie), ale mogą nie motywować do działania w kierunku celu. Inne pozytywne bodźce (np. związane z entuzjazmem, zainteresowaniem) również mogą powodować pozytywne doświadczenie, a także zwiększać motywację do dążenia. Koncepcja intensywności motywacji emocji jest określona specyficzną (związaną z emocją) potrzebą angażowania się w zachowanie lub impulsem do w kierunku bodźca (Gable, Harmon-Jones, 2010). Emocje cechujące się niską motywacją do dążenia wpływają na rozszerzanie perspektywy myślenia i pola uwagi, umożliwiające widzenie i realizację nowych możliwości (Fredrickson, 2001, 2013). Natomiast emocje cechujące się wysoką motywacją do dążenia zawężają pole uwagi, koncentrując ją na wybranym aspekcie, bez dodatkowego skupiania się na zewnętrznych dystraktorach, niezależnie czy odnosi się to do pozytywnych emocji (np. entuzjazmu; Gable, Harmon-Jones, 2008, 2010; Harmon-Jones i in., 2011), czy negatywnych emocji (np. złości; Harmon-Jones i in., 2011, Harmon-Jones i in., 2013).

Ponadto, wbrew powszechnej regule, pozytywna walencja afektu nie jest konieczna dla występowania motywacji do dążenia. Przykładem może być złość (klasyfikowana jako podstawowa emocja negatywna), która jest uważana za emocję powodującą wysoką motywację do dążenia (Carver, 2004; Carver, Harmon-Jones, 2009; Harmon-Jones i in., 2013). Osoby w złości są zmotywowane do pokonania przeszkody uniemożliwiającej podążanie do upragnionego celu, by zmniejszyć negatywne odczucia sytuacyjne.

W badaniu wpływu emocji na przebieg występu e-sportowego skupiono się na rozbawieniu, entuzjazmie, smutku i złości. W ten sposób przetestowane zostały emocje o pozytywnej i negatywnej walencji afektu oraz wysokiej i niskiej motywacji do dążenia, które występują w trakcie rozgrywki e-sportowej. Rozbawienie jest emocją, która pojawia się w reakcji na coś śmiesznego, humorystycznego (Griskevicius i in., 2010) oraz wydarzenia, które naruszają oczekiwania (McGraw & Warren, 2010), głównie z powodu działań innych (Tong, 2015). W trakcie gry taka emocja może pojawić się głównie w trakcie rozgrywek rekreacyjnych, rzadziej w przypadku meczy o stawkę. Niemniej jednak nawet w przypadku poważnych meczy, gdy gracze posiadają dużą przewagę nad przeciwnikiem, pozwalają sobie czasami na moment rozluźnienia i zabawne rozwiązania w trakcie gry.

Entuzjazm jest emocją o wysokiej intensywności powstającej w reakcji na nowość, wyzwanie i doskonałość ludzkiego działania, często doświadczana, gdy istnieje jakieś ryzyko (Cowen, Keltner, 2017; Ekman, Cordaro, 2011). W trakcie gry może pojawiać się w przypadku dobrej passy, skutecznych rozwiązań technicznych, taktycznych czy wygranego meczu przeciwko trudnym rywalom w prestiżowym turnieju.

Smutek jest wywoływany przez sytuacje związane z nieodwołalną utratą ważnej osoby lub przedmiotu (Lazarus, 1991). Doświadczenie smutku kieruje uwagę jednostki do wewnątrz, promując rezygnację, akceptację i refleksję (Lazarus, 1991; Bonanno, Keltner, 1997, Oatley i in., 1996). W przypadku gry, smutek może pojawić się w momencie, gdy osoba przegrywa mecz oraz traci nadzieję na możliwość kontynuacji dalszej walki, będąc przekonaną o niewystarczającym poziomie własnych umiejętności.

Złość powstaje na skutek pojawienia się przeszkody utrudniającej osiągnięcie celu, w celu usprawnienia odpowiedzi fizjologicznej mającej zmobilizować rezerwy energetyczne konieczne do przezwyciężenia przeszkody (Ekman, Cordaro, 2011). Podczas gry złość może pojawić się po przegranym meczu, gdy przeciwnik skutecznie utrudnia zawodnikowi osiągnięcie celu. Jednak w przeciwieństwie do smutku, złość występuje u graczy, którzy są przekonani o dalszej możliwości zdobycia celu.

Opierając się na przytoczonej teorii i badaniach, oczekiwano, że złość i entuzjazm (pomimo ich podstawowych różnic w walencji afektu) wzbudzą stan wyzwania w trakcie rozgrywki e-sportowej, co w konsekwencji powinno wiązać się lepszymi wynikami osiąganymi przez graczy.

Rola Emocji w Występach Sportowych

Emocje mogą być korzystne lub szkodliwe w zależności od kontekstu. Emocje są korzystne, gdy odpowiednio kierują przetwarzaniem sensorycznym (Aviezer i in., 2008), usprawniają proces decyzyjny (Isen, 2008), czy też motywują zachowania właściwe społecznie (Averill, 2012). Przykłady korzystnych emocji obejmują epizody: strachu, które prowadzą nas do unikania potencjalnie zagrażających aktywności (np. jazdy rowerem w trakcie śnieżycy); radości, które wzmacniają nowe przyjaźnie; złości, która motywują do walki z niesprawiedliwością lub złym traktowaniem. Warto zauważyć, że użyteczność emocji, nie zależy od znaku subiektywnego doświadczenia, również negatywne emocje mogą być użyteczne (Tamir i in., 2008). Emocje są szkodliwe, gdy mają niewłaściwą intensywność, czas trwania, częstotliwość lub powstają w niewłaściwych okolicznościach (Gross, Jazaieri, 2014).

Pomimo tego, że emocje są integralną częścią występów sportowych (Hanin, 2007; Robazza, 2006; Uphill, Jones, 2007), jedynie nieliczne badania eksperymentalne pokazały, jak wybrane emocje wpływają na występy sportowe (Davis i in., 2010; Rathschlag & Memmert, 2013, 2015; Woodman i in., 2009). Badania wykazały, że wspomnienie radości promowało lepsze wyniki w biegach sprinterskich, w porównaniu do wspomnienia stanów neutralnych i lęku (Rathschlag i Memmert, 2015). Przywołanie radości i gniewu promowało lepsze wyniki w testach wytrzymałościowych i w skoku w wzwyż w porównaniu z przywołaniem stanu neutralnego, lęku i smutku (Rathschlag & Memmert, 2013). Co więcej, osoby, które

wyobrażały sobie sytuację związaną ze złością wykazywały się lepszymi wynikami w testach wysiłkowych
w sportach walki w porównaniu do wyobrażeń sytuacji związanych ze stanem neutralnym i radością (Davis i in., 2010; Woodman i in., 2009). Dodatkowo, badania przekrojowe wykazały, że doświadczanie emocji pozytywnych, o silnej motywacji do dążenia, takich jak ekscytacja i radość (Uphill i in., 2014; Vast i in., 2010), wiązało się z udanymi występami, podczas gdy doświadczanie emocji negatywnych, o niskiej motywacji do dążenia, takich jak lęk i wstyd, wiązało się z nieudanymi występami (Uphill i in., 2014; Vast i in., 2010; Woodman, Hardy, 2003).

Choć przytoczone wyniki są obiecujące, nie jest jasne, co napędza te korzystne z perspektywy występu efekty. Badania w sporcie wykazały, że zawodnicy odnoszą korzyści z zarówno negatywnych emocji o wysokiej motywacji do dążenia (złość), jak i pozytywnych emocji o wysokiej motywacji do dążenia (radość, ekscytacja) w porównaniu do negatywnych emocji niskiej motywacji do dążenia (tj. lęk i smutek) (Rathschlag & Memmert, 2013, 2015). Na podstawie tych ustaleń, motywacja do dążenia może być kluczowym elementem udanych występów.

Warto jednak zauważyć, że w poprzednich badaniach na temat sportu nie kontrolowano poziomu motywacji do dążenia. Można oszacować jej poziom, dzięki wynikom innych badań, które wzbudzały wybrane emocje i mierzyły poziom motywacji do dążenia. Ogranicza to możliwość wnioskowania, ponieważ złość, która jest generalnie związana z motywacją do dążenia (Harmon-Jones i in., 2013) może być również związana z motywacją do unikania w sytuacjach, które mogą wzbudzać jednocześnie złość i lęk (Kaczmarek, Behnke, Enko i in., 2019; Zinner i in., 2008). Innym ograniczeniem wcześniejszych badań jest fakt, że nie porównywano w nich wielu pozytywnych emocji, a zatem nie można określić, czy korzystne dla występu efekty wzbudzone przez radość wynikały z pozytywnej walencji afektu czy motywacji do dążenia. Rozróżnienie pomiędzy pozytywnymi emocjami związanymi z wysokim i niskim poziomem motywacji do dążenia jest konieczne, aby zrozumieć rolę emocji, które miałyby sprzyjać osiąganiu lepszych wyników w sporcie.

E-sport jako Nowe Zjawisko Społeczne oraz Nowy Obszar Badań

Do badania czynników, które usprawniają skuteczne działania w sytuacji zadaniowej, skupiono się na e-sporcie. E-sporty to najszybciej rozwijający się obszar w dziedzinie sportu, w którym jednostki konkurują ze sobą za pomocą gier wideo. Gracze to wysoce zmotywowane osoby, które regularnie trenują, aby rozwijać swoje umiejętności i rywalizować (Pedraza-Ramirez i in., 2020). Rywalizacja e-sportowa obejmuje podobne procesy psychologiczne, jak przypadku tradycyjnych sportów, takie jak podejmowanie trafnych decyzji, kreatywne myślenie i dogłębna wiedza na temat uprawianej dyscypliny (Pedraza-Ramirez i in., 2020). Ponadto, rozwój technologii pozwala na prowadzenie zawodów e-sportowych w całości online, bez konieczności fizycznego kontaktu pomiędzy graczami (np. podczas lockdownu związanego z SARS-COV-2, e-sport pozostał jedną z niewielu w pełni dozwolonych form rywalizacji sportowej). W e-sportach gracze rywalizują w pozycji siedzącej przed monitorem, co stanowi doskonałą okazję do badania reakcji psychofizjologicznych związanych z występem w warunkach laboratoryjnych, które są również trafne ekologicznie. Podsumowując, w tym projekcie skupiono się na e-sportach ze względu na ich nowatorstwo, niezwykle szybko rosnącą popularność i kompatybilność z psychofizjologicznymi badaniami laboratoryjnymi.

Gry wideo

Raporty komercyjne wskazują, że ponad 75% użytkowników Internetu w Polsce, gra w gry wideo przynajmniej raz w tygodniu (Bobrowski i in., 2019). Dzięki współczesnej technologii granie jest możliwe praktycznie w każdym miejscu i czasie, wykorzystując do tego komputery osobiste, laptopy, urządzenia przenośne (iPady, tablety), konsole domowe (Play Station, Xbox360, Wii), konsole podręczne (PSP, Nintendo Wii) czy smartphony. Dodatkowo wykorzystanie mobilnego Internetu pozwala grać praktycznie w każdym miejscu, nawet z osobami znajdującymi się na drugim krańcu globu. Ważną cechą gier wideo jest ich interaktywność. Gracze nie mogą biernie podporządkować się fabule gry. Zamiast tego muszą aktywnie angażować swoje zasoby, by osiągać wyznaczane cele.

Początkowo większość badań dotyczących gier wideo koncentrowała się na negatywnych aspektach związanych z grą np. agresją (Sherry, 2001) czy uzależnieniem (Fisher, 1994). Jednak wiele współczesnych badań wskazuje na pozytywny wpływ grania w gry wideo u większości graczy (Granic i in., 2014; Kutner, Olson, 2008; Pedraza-Ramirez i in., 2020). Odpowiednio zaprojektowane i wykorzystywane gry wideo mogą przyczynić się do wzrostu pozytywnych emocji i dobrostanu (Allahverdipour i in., 2010; Kaczmarek, Drążkowski, 2014; Kutner, Olson, 2008; Ryan i in., 2006; Przybylski i in., 2009, 2011; Wang i in., 2008). Granie w gry wideo może być również skutecznym narzędziem w redukcji stresu (Russoniello i in., 2009; Snodgrass i in., 2011; Wack, Tantleff-Dunn, 2009). Dzięki przezwyciężaniu trudności i zdobywaniu umiejętności w trakcie gry, gracze mogą zwiększać poczucie własnej skuteczności, poprawiać identyfikację z grupą społeczną, które mogą wpływać na ich dobrostan (Tian, 2009). Co istotne, ważny jest umiarkowany poziom grania, który w przeciwieństwie do nadmiaru lub braku grania, niesie ze sobą pozytywne konsekwencje (Wack, Tentelett-Dunn 2009).

E-sport

E-sport jest terminem nadrzędnym dla zorganizowanych i ustrukturalizowanych rozgrywek gier wideo, np. w postaci turniejów (Whalen, 2013). Jest on nowym zjawiskiem społecznym wynikającym z coraz większej liczby gier e-sportowych, amatorów i zawodowych graczy, kibiców oraz sponsorów. Zwiększone zainteresowanie grami wideo doprowadziło do powstania rywalizacji między graczami, która dalej przekształciła się w zawodowe ligi i profesjonalne turnieje organizowane przez międzynarodowe organizacje e-sportowe (Hutchins, 2008; Wagner, 2006).

Według teoretyków sportu, by dana aktywność została uznana za sport musi spełniać kilka kryteriów (Guttmann, 2004; Suits, 2007): 1) posiadać element zabawy (działalności motywowanej wewnętrznie, czyli podejmowanej dla przyjemności czerpanej z niej samej); 2) być zorganizowana (regulowana przepisami, np. ustalanymi przez międzynarodowe organizacje); 3) zawierać element rywalizacji; 4) być oparta na wytrenowanych umiejętnościach (a nie przypadkowych działaniach); 5) obejmować umiejętności fizyczne - umiejętne i celowe wykorzystanie swojego ciała; 6) mieć szeroką publiczność; 7) posiadać stabilność instytucjonalną (np. organizacje międzynarodowe, związki sportowe, kluby sportowe), która ją reguluje i stabilizuje jako ważną aktywność społeczną. Współczesny e-sport spełnia wszystkie z wyżej wymienionych wymogów (Jonasson, Thiborg 2010). Dzięki temu, rozpoczęto proces nadzorowany przez Międzynarodową Federację E-sportową (IeSF), mający na celu uznanie e-sportu przez Międzynarodowy Komitet Olimpijski (MKOL) za nową dyscyplinę sportową.

Gracze

Zakładając, że e-sport jest dyscypliną lub grupą dyscyplin sportowych, należy przyjąć odpowiednią terminologię dla nazywania osób uprawiających ten typ aktywności. W związku z tym powstały najczęściej używane terminy e-sportowiec, cyber-zawodnik (*cyberathlete*) (Hutchins, 2008). Jednak te sformułowania odnoszą się do profesjonalnych zawodników startujących w zorganizowanych zawodach czy rozgrywkach ligowych, rywalizujących o nagrody i trofea. Dodatkowo oba te sformułowania sugerują, że zawodnicy Ci byli wirtualnymi sportowcami, a ich umiejętności również istniały jedynie w grze. Idąc tym torem rozumowania można pomylić umiejętności zawodników z cechami, umiejętnościami postaci, które kontrolują podczas gry. Jednak jak wskazują badania, gracze w trakcie rozgrywek muszą wykazywać się realnymi, specyficznymi umiejętnościami m.in. technicznymi, taktycznymi oraz motorycznymi (np. koordynacja wzrokowo-ruchowa) (Reeves i in., 2009; Taylor, 2012;

Whalen, 2013). Ponadto termin e-sportowiec, kojarzy się jednoznacznie z rozgrywkami sportowymi i może on mylnie wskazywać na treść gry, która w tym rozumieniu miałaby mieć tematykę sportową (Hutchins, 2008). Wśród gier wybieranych do prestiżowych rozgrywek World Cyber Games, czy też Major League Gaming jedynie jedna gra miała tematykę sportową (FIFA). Największą popularnością cieszą się gry typu: first person-shooter np. Counter Strike Global Offensive, Dota 2, oraz gry strategiczne np. Starcraft II. Ponadto wielu graczy przyznaje, że ciężko jest im zdefiniować siebie jako sportowców (Taylor, 2012). Dlatego też zgodnie z terminologią anglojęzyczną osobą grającą w celach rekreacyjnych nazywa się graczem lub gamerem, a profesjonalnych zawodników nazywa się profesjonalnym graczem lub pro-gamerem (Taylor, 2012).

Z perspektywy psychologicznej gracze startujący w zawodach, podlegają w większości tym samym wymaganiom co klasyczni sportowcy (Hilvoorde, Pot, 2016). Istnieją jednak istotne wyjątki charakterystyczne dla e-sportu. Po pierwsze, gracze będąc w stanie wysokiego pobudzenia fizjologicznego (grając w pozycji siedzącej), realizują większość działań jedynie symbolicznie w trakcie rozgrywki osadzonej w świecie wirtualnym (np. skoki, bieg wykonany przez avatara). Aktywność fizyczna związana z grą ogranicza się do kontrolowania myszki i klawiatury. Daje to unikalną sytuację, w której można obserwować procesy psychofizjologiczne bez zakłócania (lub z niewielką ingerencją) specyficznej dla sytuacji aktywności motorycznej. Sami gracze przyznają, że e-sport i tradycyjne sporty łączy rywalizacja, która jest jednym z głównych motywów podejmowania tej formy aktywności (Bowers, 2011; Jansz, Martens, 2005; Taylor, 2012).

Rywalizacja e-sportowa najczęściej toczy się za pośrednictwem Internetu lub za pośrednictwem tak zwanych sieci lokalnych. Profesjonalne turnieje, np. World Electronic Sport Games oferują nagrody w wysokości 1,5 milionów dolarów (Valve Corporation, 2017). Struktura rywalizacji w czasie takich turniejów przypomina klasyczne turnieje sportowe, z fazą grupową oraz tzw. systemem drabinkowym. Zawody e-sportowe są oglądane przez dziesiątki tysięcy widzów zgromadzonych w hali oraz miliony osób śledzących relacje on-line w Internecie, przez co gracze muszą poradzić sobie nie tylko z przeciwnikami, ale też z ekspozycją społeczną (Reeves i in., 2009).

Gry wideo *Counter-Strike i FIFA*

W niniejszym projekcie skupimy się na dwóch grach, które są jednymi z najpopularniejszych gier wideo, wykorzystywanych w turniejach e-sportowych, mianowicie grą Counter-Strike: Global Offensive (Valve Corporation, USA) oraz serią gier FIFA (Electronic Arts Inc., USA). Podczas gry w Counter-Strike dwie drużyny rywalizują ze sobą w symulowanej walce wojskowej (tzw. strzelance pierwszoosobowej). Celem drużyny terrorystycznej jest atak z zamiarem podłożenia bomby na jednym z wyznaczonych pól, natomiast zespół antyterrorystyczny, próbuje powstrzymać rywali przed skutecznym zdetonowaniem bomby. Opozycyjne zespoły mają na celu usunięcie rywali z pola gry (tzw. fragging). W serii gier FIFA gracze rywalizują ze sobą grając w wirtualną wersję piłki nożnej opartą na zasadach obowiązujących na boiskach na całym świecie. Zadaniem drużyny kontrolowanej przez gracza jest trafienie więcej bramek niż drużyna przeciwna. Powodem, dla którego w przedstawionym projekcie, e-sportowa rywalizacja będzie toczona w dwie wcześniej wymienione gry, jest duża popularność obu gier oraz wysoki poziom graczy w Polsce.

Projekt Badań Własnych

Projekt badawczy przedstawiony w pracy doktorskiej składa się z trzech badań powiązanych problematyką fizjologicznych wskaźników wyzwania i zagrożenia w trakcie aktywności zadaniowej człowieka.

W badaniu pierwszym została przeprowadzona meta-analiza, na podstawie której określono średni efekt związku reaktywności parametrów układu krążenia – objętości minutowej serca, oporu obwodowego oraz skuteczności występu (Behnke, Kaczmarek, 2018). Meta-analiza miała na celu uzyskanie wsparcia dla podstawowych założeń bio-psycho-społecznego modelu wyzwania i zagrożenia, według którego skuteczność występu wiąże się ze specyficzną aktywnością układu krążenia. W pracy przedstawiono nowe dowody na znaczenie wskaźników aktywności układu krążenia – objętości minutowej i całkowitego oporu obwodowego - w przewidywaniu udanych występów. Wykazano, że osiąganiu lepszych wyników sprzyja podwyższona mobilizacja fizjologiczna - wzrostu objętości minutowej serca oraz spadek oporu obwodowego. Wielkość efektu należy jednak interpretować jako małą. Otrzymane wyniki stanowią istotny wkład do literatury, ponieważ dokumentują one znaczenie wskaźników fizjologicznych dla powodzenia występu, a także przedstawiają ich ograniczenia.

W badaniu drugim został przeprowadzony eksperyment laboratoryjny na próbie 82 graczy, mający na celu przeniesienie wcześniejszych badań ugruntowanych na bazie modelu bio-psycho-społecznego w obszar problematyki e-sportowej (Behnke, Kosakowski i in., 2020). W tym celu została stworzona procedura laboratoryjna badania w formie turnieju e-sportowego. W badaniu zastosowano model wyzwania i zagrożenia do specyficznej sytuacji występu e-sportowego. Planowano wykazać trafność modelu, który zakładał, że określone zmiany na poziomie poznawczym i fizjologicznym świadczące o ocenie sytuacji jako wyzwanie lub zagrożenie wiążą się ze skutecznością graczy. Zakładano, że stan motywacyjny związany z wyzwaniem będzie czynnikiem podnoszącym skuteczność działania graczy w porównaniu do stanu zagrożenia. W badaniu wykazano trafność bio-psycho-społecznego modelu wyzwania i zagrożenia, replikując cześć jego założeń. Wykazano, że gracze z większym doświadczeniem w grze, lepiej oceniali swoje możliwości w kontekście wymagań sytuacyjnych, co w rezultacie przenosiło się na ich większe zaangażowanie fizjologiczne i lepsze rezultaty w trakcie gry. Do mocnych stron tego badania należy zaliczyć zaawansowaną metodologię do badania czynników usprawniających działania graczy. Starano się uzupełnić aktualny stan wiedzy, badając zjawiska w trakcie zorganizowanej rywalizacji (Turner i in., 2012). W ten sposób osiągnięto stosunkowo wysoką ważność ekologiczną, podobną do autentycznych zawodów e-sportowych z nagrodami (King i in., 2009). Stosując wielowymiarowe podejście, zaobserwowano jak ewaluacja, w kontekście porównań z innymi, wpływa na reakcje fizjologiczne, które pośredniczyły pomiędzy efektami ewaluacji, a wynikami gry.

W badaniu trzecim został przeprowadzony eksperyment laboratoryjny na grupie 241 graczy, gdzie skupiono się na czynnikach, które mogłyby usprawnić działanie graczy, przez wzbudzenie stanu wyzwania (Behnke, Gross i in., 2020). W tym celu wykorzystano motywacyjny dymensjonalny model afektu, który podkreśla rolę emocji sprzyjających wysokiej intensywności motywacyjnej (Gable, Harmon-Jones, 2010). Przed rozgrywką, gracze oglądali krótkie filmiki, które miały wzbudzić u nich wybrane emocje. Zakładano, że wzbudzone emocje związane z silną motywacją do dążenia (np. entuzjazm czy gniew), zmobilizują zasoby fizjologiczne (których miarą były wzory reakcji układu krążenia - wzrost objętości minutowej serca) i przełożą się na podwyższenie skuteczności działania graczy (w kontraście do emocji o niskiej motywacji do dążenia, np. rozbawienie, smutek). W badaniu wykazano, że emocje wpływają na usprawnienie działania graczy tak długo, jak wzbudzają silną motywację do dążenia. Wyniki badania trzeciego pokazały, w jaki sposób motywacja do dążenia i walencja afektu przyczyniają się do usprawnienia działania osób występujących. Ponadto gracze o silnym przekonaniu na temat swoich możliwości i angażujący więcej zasobów fizjologicznych w trakcie gry (stan wyzwania) osiągali lepsze wyniki. Do mocnych stron tego badania należy zaliczyć podejście eksperymentalne z dużą liczą osób badanych, dla których występ łączył się z ich zainteresowaniami. W tym badaniu również wykorzystano wielowymiarowe podejście do badania reakcji afektywnych, poznawczych i fizjologicznych w tym kontekście występu e-sportowego. Badanie to pomogło wyjaśnić związek między emocjami, stanami wyzwania i zagrożenia, a wynikami sportowymi.

Podsumowanie

Celem tego projektu było zastosowanie modelu bio-psycho-społecznego do problematyki wyjaśniania i kształtowania wyników esportowych. Wartość tego celu można rozpatrywać z dwóch perspektyw: wykorzystanego modelu oraz podjętej problematyki. Z perspektywy modelu bio-psycho-społecznego w niniejszym projekcie udało się przeprowadzić nowe analizy pokazujące trafność wskaźników sercowo-naczyniowych w przewidywaniu efektów aktywności zadaniowej. Cel ten zakończył się sukcesem, którego miarą może być to, że praca metaanalityczna (Behnke et al., 2018) stała się w krótkim czasie jedną z podstawowych prac cytowanych na potwierdzenie istotności związku między sercowo-naczyniowymi wskaźnikami wyzwania i zagrożenia a późniejszymi efektami behawioralnymi. Z kolei, z perspektywy problematyki e-sportu, przeprowadzone badania dostarczyły dość praktycznej wiedzy potwierdzającej korzystną rolę pozytywnych przekonań oraz pozytywnych emocji wśród czynników psychologicznych, które mogą sprzyjać rozgrywce e-sportowej. Również i ten aspekt projektu można uznać za zakończony sukcesem, ponieważ badania zostały docenione przez środowisko naukowe (m.in. drugi artykuł wchodzący w cykl publikacji – Behnke, Kosakowski i in., 2020 – został uznany za najlepszą oryginalną pracę twórczą doktoranta w roku 2019, w obszarze nauk humanistycznych i społecznych, w konkursie organizowanym przez Prezydium Oddziału Polskiej Akademii Nauk w Poznaniu) oraz środowisko graczy w postaci Nagrody Inteligentnego Rozwoju 2020, w kategorii Naukowiec Przyszłości.

W przedstawionym projekcie wykazano, że wzmożona aktywność układu krążenia łączy się uzyskiwanymi lepszymi wynikami w trakcie występów sportowych. Wykorzystując podejście meta-analityczne (badanie 1) oraz eksperymentalne (badanie 3) zreplikowano jedno z głównych założeń bio-psycho-społecznego modelu wyzwania i zagrożenia, wg którego zwiększona objętość minutowa krwi stanowi fundament do optymalnego działania osób w sytuacji zadaniowej (Blascovich, 2008). W badaniu 2, natomiast wykazano, że podwyższona częstotliwość skurczów serca również korzystnie wpływa na wyniki osiągane przez graczy w trakcie turnieju e-sportowego. Podsumowując, projekt ten wskazał, że wyższa mobilizacja fizjologiczna u graczy sprzyja osiąganiu lepszych wyników (Seery, 2011). Tym samym projekt ten może stanowić podstawę do dalszych badań nad psychofizjologicznymi uwarunkowaniami sukcesu w e-sporcie.

Ponadto w obu badaniach eksperymentalnych wykazano rolę doświadczenia graczy dla uzyskiwanych przez nich wyników w trakcie rywalizacji. Wykorzystano dwa wskaźniki doświadczenia graczy tj. sumę godzin poświęconych na grę od początku jej powstania (badanie 2) oraz sumę godzin poświęconych na grę w trakcie typowego tygodnia (badanie 3). W obu badaniach bardziej doświadczeni gracze uzyskiwali lepsze wyniki w trakcie rozgrywki e-sportowej. Kontrola doświadczenia graczy była uzasadniona, ponieważ w badaniach brali udział gracze o różnym poziomie doświadczenia. Niemniej jednak, w obu badaniach wzięli udział gracze wykazujący się ekspertyzą w wykorzystywanych grach. Dzięki temu zabiegowi, w badaniach przetestowano założenia teoretyczne w kontekście występów, które były podstawą zainteresowań osób badanych. Dzięki rekrutacji doświadczonych graczy do badań nad uwarunkowaniami sukcesu w e-sporcie uzyskano trafny ekologicznie kontekst badań.

Duże doświadczenie graczy, mogło mieć również wpływ na brak zaobserwowanych bezpośrednich efektów manipulacji eksperymentalnej na wyniki uzyskiwane przez graczy. Pomimo tego, że w obu badanych manipulacja eksperymentalna przyniosła oczekiwane efekty na poziomie poznawczym, sama manipulacja komunikatem zwrotnym (badanie 2) oraz emocjami (badanie 3) nie miała bezpośredniego wpływu na wyniki graczy. Gracze, którzy spędzili na treningu swoich umiejętności e-sportowych setki, a czasem nawet tysiące godzin, podchodzili

do rozgrywek w pewien wytrenowany sposób. Przez co manipulacja eksperymentalna mogła mieć jedynie pośredni efekt na wyniki graczy. Niemniej jednak, w profesjonalnym sporcie i esporcie, zawodnicy często prezentują bardzo zbliżony poziom umiejętności sportowych, a wygrana lub przegrana zależy od czynników peryferyjnych (Gould, Dieffenbach, i in., 2002; Gould, Greenleaf i in., 2002; Pedraza-Ramirez i in., 2020). Dlatego też nawet czynniki, które wykazują jedynie pośredni efekt dla osiąganych wyników mogą mieć kluczowe znaczenie.

Podsumowując niniejsza praca doktorska przyczyniła się do rozwoju wiedzy w kilku obszarach psychologii, włączając w to psychologię emocji (np. nowe dowody dla rozbieżności funkcji emocji o wysokiej i niskiej motywacji do dążenia), psychologię sportu (np. rozwój metod możliwych do wykorzystania w treningu graczy), oraz psychofizjologię (np. nowe dowody na trafność bio-psycho-społecznego modelu wyzwania i zagrożenia).

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Załączniki

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Załącznik 1

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Review

Successful performance and cardiovascular markers of challenge and threat: A meta-analysis

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ABSTRACT

Cardiovascular responses to challenge and threat have been used extensively in psychophysiological research. In this meta-analysis, we scrutinized the body of evidence for the role of challenge and threat hemodynamic responses in predicting positive behavioral outcomes, i.e., performance quality. We accounted for cardiac output (CO), total peripheral resistance (TPR), and Challenge-Threat Index (CTI). With 17 articles covering 19 studies (total $N = 1045$), we observed that the literature might have been biased towards positive results. After we excluded outlying studies and compensated for missing null-effect studies, we found that the mean standardized coefficient, corrected with the trim-and-fill method, was $r = 0.14$ for CO, $r = -0.13$ for TPR, and $r = 0.10$ for CTI. This indicated relatively small but stable effects of cardiovascular responses in the facilitation of successful performance. Moderator analyses indicated that TPR and CTI produced stronger effects in non-experimental studies. We also found that effects were not moderated by levels of engagement (indexed by heart rate and pre-ejection period), task domain (cognitive vs. behavioral) and measurement method. In summary, our results supported the general validity of the biopsychosocial model in the prediction of behavioral outcomes. However, they also indicated limitations of the empirical evidence and a significant bias in the literature.

1. Introduction

The challenge and threat paradigm has become one of the leading theoretical frameworks for physiological responses during a motivated performance (Blascovich et al., 2004; Seery et al., 2009; Turner et al., 2012). Challenge and threat studies capitalize on cardiovascular (CV) biosignals that provide continuous and relatively unobtrusive access to the correlates of action-oriented cognitive processes (Seery, 2013). The challenge and threat cardvioascular response has been studied to identify inibiting and facilitating factors in several diverse contexts of daily life such as coping with stereotype threat among minority members and women (Mendes et al., 2008), training skills, e.g., laparoscopic surgery (Vine et al., 2013), practicing sports, e.g., climbing (Turner et al., 2014), taking exams (Seery et al., 2010), or negotiating (Scheepers et al., 2012).

The concept of healthy and unhealthy responses to demanding tasks, such a challenge vs. threat cognitive appraisal (Lazarus and Folkman, 1984) or eustress vs. distress (Selye, 1976), has been discussed in the literature for decades. However, there has been a more recent and ongoing debate within the literature regarding the physiological specificity of these cognitive processes (Wright and Kirby, 2003). For instance, theorists have argued for specific CV (Blascovich, 2008), hormonal (Jamieson et al., 2010), and behavioral (Jones et al., 2009) responses to challenge and threat appraisals as well as their role in the facilitation of goal-oriented actions. Some authors have claimed that CV markers of challenge and threat are superior in comparison to self-reported evaluations because an accurate report of inner states and experiences is likely to be problematic to some individuals and is not feasible for some research designs (Seery et al., 2010, Nisbett and Wilson, 1977). The validity of CV markers of challenge and threat has also been supported experimentally because individuals with stronger challenge-type CV responses are more successful at goal attainment (Gildea et al., 2007; Moore et al., 2012).

Building upon these works, we have used a metanalytical approach to test the overall strength and consistency of relationships between challenge and threat physiological markers and successful performance across different life domains. Scrutinizing the body of empirical evidence for the biopsychosocial model is worthwhile because it summarizes what studies have been conducted and evaluates their strengths and limitations, e.g., the diversity of tested populations, research designs, or methods of measurement. Meta-analyses are robust tests for theories that inform meaningful decision in further studies, e.g., which populations or types of activity are understudied or what effects sizes could be expected while determining the sample size. Finally, a meta-

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analysis is likely to provide an empirical test for the integrity of the literature, revealing or discarding the occurrence of any publication-bias.

1.1. Physiological responses to challenge and threat

Challenge and threat appraisals occur when individuals are motivated to engage in active goal pursuits and do their best, e.g., while taking school exams (Seery et al., 2010), negotiating prices (Scheepers et al., 2012), or learning new skills (Moore et al., 2014). Cognitive evaluations of the self and the environment feed the motivational system that mobilizes the physiological resources that are necessary for action (Mendes and Park, 2014). Increased goal-oriented motivation leads to increased sympathetic activation in the autonomous nervous system, which results in increased heart rate (HR) and shortened pre-ejection period (PEP) (Seery, 2011). Thus, individuals with stronger motivational intensity display higher HR and PEP reactivity. This initial physiological response is further modulated after individuals evaluate personal action resources (e.g., skills, knowledge, and abilities) and situational demands (e.g., solutions that need to be found using cognitive skills or motor actions that require considerable dexterity).

Challenge motivation occurs when individuals identify the sufficiency of resources to overcome demands. Adrenaline is released into the bloodstream, which results in widening of blood vessels (vasodilatation) and this then produces lower total peripheral resistance (TPR) (Brownley et al., 2000). It also results in higher cardiac output (CO) (i.e., the amount of blood pumped by the heart). In contrast, when demands exceed personal resources, individuals perceive the situation as threatening. Threat appraisal inhibits the release of adrenaline and instead releases cortisol. In these circumstances, the arteries narrow, despite the increased HR. This results in higher TPR with relatively lower CO. This CV pattern has been related to challenge and threat using several manipulations. For instance, challenge and threat was induced by changing the task difficulty (Fonseca et al., 2014), introducing the presence of an audience (Feinberg and Aiello, 2010), changing the gain and loss probability (Seery et al., 2009), or using downward and upward social comparison opportunities (Mendes et al., 2001).

The following four indexes of CV reactivity have been used within the challenge and threat paradigm: HR, PEP (i.e., time in the cardiac cycle from initiation of ventricular depolarization to the opening of the aortic valve and ejection of blood into the vasculature), CO (i.e., the amount of blood pumped by the heart per minute), and TPR (i.e., net constriction vs dilation in the arterial system). TPR has been typically calculated by dividing mean arterial pressure by CO and then multiplying the total by 80 (Sherwood et al., 1990). Several authors have used the Challenge-Threat Index (CTI), which integrates the TPR and CO information, based on the assumption that the TPR and CO are two related measures of the same underlying nervous system activation (Blascovich et al., 2004). For instance, CTI can be used in regression analysis by converting TPR and CO values into z-scores and summing them, with an assigned weight of -1 for TPR and 1 for CO. The theoretical framework for these CV responses was built upon Dienstbier's (1989) model of psychophysiological toughness, which has since been validated (see Blascovich, 2008; Seery, 2011 for reviews).

1.2. Challenge, threat, and performance

The challenge-type CV response is more efficient at energy mobilization than the threat-type because it provides greater blood flow to the periphery (Seery, 2011). Previous research has shown that individuals who endorse a challenge-type motivation are more likely to achieve a superior performance in cognitive tasks (Gildea et al., 2007; Mendes et al., 2008; Turner et al., 2012), and motoric activities (Blascovich et al., 2004; Moore et al., 2012; Moore et al., 2013; Turner et al., 2013). Furthermore, challenge and threat CV markers predict academic success (e.g., Seery et al., 2010). These findings indicate that challenge and threat CV responses predict a broad range of behavioral outcomes.

1.3. Present study

The present study aims to test whether or not CV responses to threat and challenge are related to a successful performance. While studies have reported significant effects (Turner et al., 2012) and some have reported null-effects (Moore et al., 2012), it was imperative to employ a meta-analytical approach that tests the robustness of the available findings. Furthermore, we examined the potential moderators that might explain the heterogeneity of the findings across different studies; that is, the domain of performance (cognitive vs. motor activity) and the CV markers of motivation intensity in participants to complete the task (HR and PEP reactivity). The metanalytical approach provides statistical tools that inform whether a publication bias (e.g., refraining from the publication of null findings) was likely to occur for this particular body of research (Duval and Tweedie, 2000). It is essential to account for this type of bias because the problem of poor replicability of findings in psychology has been observed (Francis, 2012). Publication bias has been indicated to be one of the main reasons for this problem.

2. Method

2.1. Search strategy

We performed a systematic literature search in PsychInfo, PubMed, and Google Scholar covering the period from 1993 (first attempt of using of challenge and threat CV markers) (Tomaka et al., 1993) to January 2017. We used the following terms: “challenge” or/and “threat” in combination with one of the other expressions: “performance,” “cardiovascular,” “CO,” “TPR,” “CTI” (for details, see Fig. 1). We also cross-checked the references in the studies that we retrieved and contacted 25 authors that had published papers on the question of challenge and threat. We asked these authors for any unpublished material. The search was restricted to peer-reviewed studies in English. A total of 20 authors responded to the request but they did not report any unpublished research results.

2.2. Selection of studies

We selected potentially eligible studies in two phases. First, we scrutinized the titles and abstracts. If the material was relevant to the subject of this meta-analysis, we then screened the full-text articles. All of the studies that were identified as potentially eligible during the first selection phase were then re-assessed in the second selection phase. The inclusion criteria were as follows: the study was developed within the challenge and threat paradigm; the performance was quantified; relevant CV markers were provided; available data of each study required for the calculation of effect sizes. If necessary, the authors were contacted for supplementary data. A total of 12 authors sent re-analyzed results with the requested coefficients.

2.3. Study coding

The first author coded all of the studies that met the inclusion criteria. The studies were then coded for the inclusion of CV reactivity measures, performed task, type of performance (cognitive vs. behavioral), type of measurement, research design (experimental manipulation vs no manipulation), number of participants, and age.

2.4. Data selection and extraction

This meta-analysis aimed to assess the effect of CV markers of challenge and threat on successful performance. Thus, we only considered those performances that had objective and quantifiable

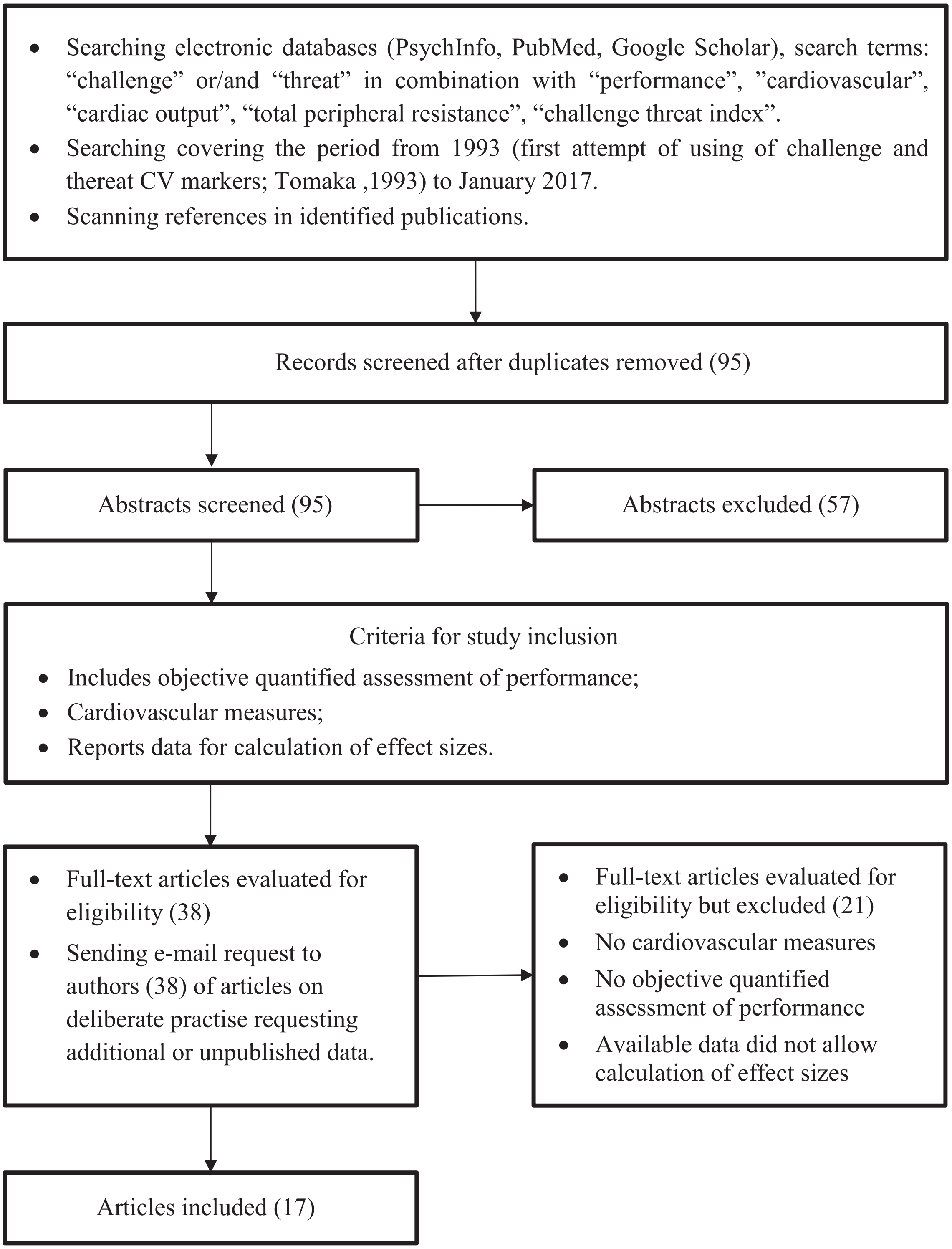

Fig. 1. Diagram of the literature search and study coding.

outcomes. Relevant data for every measure included in the analysis were extracted and entered into an Excel spreadsheet. Our search and e-mail requests yielded 38 potentially relevant articles. After examining these articles and discarding any irrelevant studies (e.g., missing objective performance outcomes), we identified 17 articles that met all of the inclusion criteria (for details, see Fig. 1). These studies included 19 independent samples, with 27 effect sizes and the total sample size of 1045 participants. A list of studies and the additional characteristics of the meta-analysis are presented in Table 1.

2.5. Meta-analysis strategy

For the meta-analysis, we used the correlation between the CV markers and the performance outcomes as a measure of the effect size. For most studies, the authors reported correlation coefficients. For studies reporting other metrics (e.g., group-level comparisons, challenge vs. threat), we sent a request to the authors to re-analyze the data and provide relevant results. To calculate the pooled mean effect sizes, we used *R* (R Core Team, 2017) with packages metafor (Viechtbauer,

Table 1
Studies examining the effects of challenge and threat CV markers on successful performance.

ID	Authors	N	CO	TPR	CTI	HR(d)	PEP(d)	Age	Measurement method	Performance task	Type	Research design
1	Blascovich et al., 2004	27	0.40	−0.40	0.46	3.61	1.93	UUS	ICG, ECG, CBP	Baseball	0	0
2	Chalabaev et al., 2009	27	0.53	−0.36	–	1.84	1.57	UUS	ICG, ECG, CBP	Problem-solving	1	1
3	Ell et al., 2011a	17	0.33	−0.22	–	0.46	−0.46	22.7	ICG, ECG, CBP	Rule-based categorization	1	0
4	Ell et al., 2011b	16	−0.67	0.71	–	0.46	−0.46	22.7	ICG, ECG, CBP	Information-integration categorization	1	0
5	Frings et al., 2015	48	–	–	−0.05	0.45	–	21.75	ICG, ECG, CBP	Word finding	1	0
6	Mendes et al., 2008	110	0.26	−0.21	–	–	1.54	UUS	ICG, ECG, CBP	Word finding	1	1
7	Moore et al., 2012	122	−0.05	0.03	−0.06	2.74	–	19.5	ICG, ECG, BP	Golf putting	0	1
8	Moore et al., 2014	115	0.13	−0.09	0.08	2.45	–	21.57	ICG, ECG, BP	laparoscopic surgery	0	1
9	Moore et al., 2015	42	0.22	−0.17	0.24	2.16	–	20.2	ICG, ECG, BP	Golf putting	0	1
10	Moore et al., 2013	59	0.04	−0.2	0.12	2.09	–	22.9	ICG, ECG, BP	Golf putting	0	1
11	Scheepers, 2009	40	−0.04	0.01	0.03	–	1.42	UUS	ICG, ECG, CBP	Word finding	1	1
12	Scheepers et al., 2012	65	−0.05	−0.01	0.05	0.69	−0.69	20	ICG, ECG, CBP	Negotiation	1	1
13	Scholl et al., 2017	49	0.27	−0.35	0.41	0.71	−1.43	22	ICG, ECG, CBP	Number bisection	1	0
14	Seery et al., 2009	72	0.21	−0.12	0.17	2.45	−1.78	UUS	ICG, ECG, CBP	Remote associations test	1	1
15	Seery et al., 2010	95	0.25	−0.22	0.25	3.15	−1.59	UUS	ICG, ECG, CBP	SAT	1	0
16	Turner et al., 2012a	25	0.35	−0.45	0.4	0.9	2.12	34	ICG, ECG, CBP	Stroop test	1	0
17	Turner et al., 2012b	21	0.33	−0.36	0.37	1.91	1.68	21.1	ICG, ECG, CBP	Netball shooting	0	0
18	Turner et al., 2013	42	0.57	−0.51	0.65	1.27	1.23	16.5	ICG, ECG, CBP	Cricket batting	0	0
19	Vine et al., 2013	52	0.18	−0.18	0.285	3.235	–	20.5	ICG, ECG, BP	Laparoscopic surgery	0	0

Note: Id = study identification number, *N* = number of participants, CO = cardiac output, TPR = total peripheral resistance, CTI = Challenge-Threat Index, HR (d) = effect size for increases in heart rate between baseline and performance, PEP(d) = effect size for increases in pre-ejection period between baseline and performance, Measurement method = method used to obtain physiological measures, type = performance type, UUS = paper characterized participants as undergraduate university students, ICG = impedance cardiography, ECG = electrocardiography CBP = continuous blood pressure, BP = blood pressure. Performance type coded 0 = behavioral, 1 = cognitive; Research design coded as 0 = non-experimental, 1 = experimental.

2010) and robumeta (Fisher and Tipton, 2015) following meta-analysis recommendations (Quintana, 2015). We decided to use the random effects model because the diversity of the outcomes in these studies was high and considerable heterogeneity was likely. Several theorists have advocated for the adoption of random effects models for meta-analysis as these models are optimal in permitting the generalization of corrected effect sizes to the population (Field, 2001; Hunter and Schmidt, 2000; Schmidt and Hunter, 2014). We tested for the presence of heterogeneity based on two parameters. First, we calculated the *Q* statistic. A significant *Q* rejects the null-hypothesis of homogeneity and indicates that the true effect size probably does vary from study-to-study. Second, the I^2-statistic was calculated. This is a percentage indicating the study-to-study dispersion due to real differences over and above the random sampling error. A value of 0% indicates an absence of dispersion and larger values show increasing levels of heterogeneity, where 25% indicates low, 50% moderate, and 75%, high heterogeneity (Higgins et al., 2003).

In line with recommendations, we performed a publication-bias analysis to investigate whether null or weak results have been systematically suppressed from publication in the challenge and threat literature (Schmidt and Hunter, 2014). We checked whether any effect sizes were likely to be missing in the meta-analysis because of the publication bias. This type of analysis is vital because studies with non-significant or negative results are less likely to be published in peer-reviewed journals (Borenstein et al., 2009). We inspected a funnel plot depicting the relationship between standard error and effect size, and then ran a trim-and-fill analysis (Duval and Tweedie, 2000).

Finally, we performed moderator analyses by testing the differences in mean correlation coefficients between subgroups. A moderator was considered effective if the average corrected effect sizes calculated in each moderator group were significantly different from each other, as evidenced by the 95% confidence intervals. Moderation was further supported if the moderator resulted in a narrowing of the credibility intervals and an increase in the variance accounted for by statistical artefacts. To report the results, we applied Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009).

Based the biopsychosocial model (Blascovich, 2008; Seery, 2013), we expected that several factors might be explored as potential moderators: a type of performance (behavioral vs. cognitive), measurement method (continuous vs. discrete measurement of blood pressure), research design (experimental manipulation vs. no manipulation), and metabolic engagement level (indexed by the reactivity measures of HR and PEP or ventricular contractility (VC)). Some studies term PEP as ventricular contractility multiplying PEP by −1 (e.g., Mendes et al., 2008). For these studies, we calculated PEP by multiplying changes in VC by −1. Examples of the type of performance included behavioral (e.g., netball shooting, laparoscopic surgery) and cognitive (e.g., modified Stroop Test performance, remote associations test (RAT)) tasks. As for the measurement methods, all studies included electrocardiography (ECG) and impedance cardiography (ICG) measures. Blood pressure was measured beat-by-beat in 14 studies, and discrete measurements were taken in five studies. Nine studies (47%) used an experimental design to influence the challenge and threat appraisal. The remaining studies measured undisturbed challenge and threat levels preceding the performance. We found no substantial diversity of studies in the sample to test differences between sports vs non-sports behavioral activity, precision movements (e.g., darts) vs gross body movements (e.g., running). This resulted from the fact that the majority of studies (n = 6, 75%) involved sports that required gross body movements, whereas only one behavioral activity used in two studies (n = 2, 25%) was non-sports (surgical skills). In contrast, the sample of studies with cognitive tasks was highly heterogenic and measured diverse cognitive skills such as attention (n = 4, 36%), reasoning (n = 3, 27%), categorization (n = 2, 18%), communication (n = 1, 9%), problem solving (n = 1, 9%). Thus, there were few studies to test differences between each cognitive category.

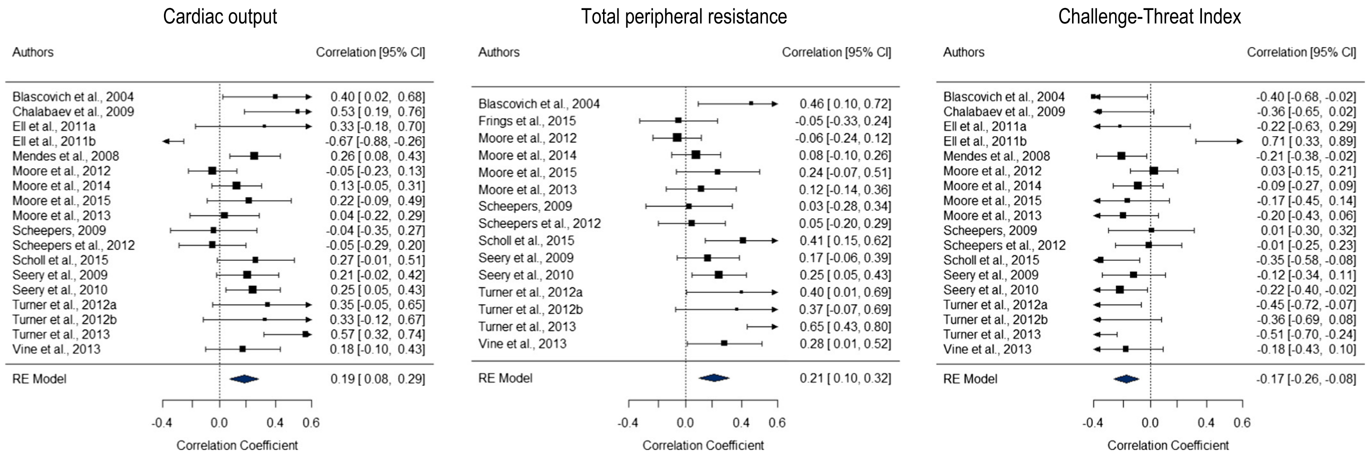

Fig. 2. Effects size of cardiac output, total peripheral resistance, Challenge-Threat Index on successful performance. The square boxes represent effect sizes and sample sizes (the larger the box, larger the sample size, contributed more to the total effect size) in each study. The lines represent 95% confidence intervals. The diamonds represent the pooled effect size and the 95% confidence intervals.

3. Results

3.1. Effect sizes

Table 1 presents the summary statistics for the studies included in the analysis. This table also provides the coding that we used to conduct the moderator analyses. Fig. 2 shows that nearly all correlations between performance outcomes and CTI, and CO were positive, and for TPR were negative. CV markers with higher reactivity levels were associated with higher levels of performance.

The analysis produced a "bare bones" correlation coefficient representing the mean average effect size corrected for the sampling error. The random effects model showed that the average Performance correlation was $r = 0.21$, 95% CI [0.10, 0.32], $p < .01$, for CTI, $r = 0.19$, 95% CI [0.08, 0.30], $p < .01$, for CO, and $r = -0.17$, 95%CI [-0.26, -0.08], $p < .01$, for TPR.

The test for heterogeneity revealed significant levels for CTI $Q(14) = 35.10$, $p < .01$, CO $Q(17) = 42.96$, $p < .01$, and TPR $Q(17) = 36.78$, $p < .01$. This rejected the null-hypothesis of homogeneity and it indicated that the true effect size was likely to vary from study-to-study. Moreover, the variability in effect sizes indicated by the I^2 statistic suggested that there were differences in the population between studies for CTI ($I^2 = 61.42$), CO ($I^2 = 60.68$), and (TPR $I^2 = 47.08$). We investigated the source of this heterogeneity through a Bajaut plot analysis, which identifies studies that contribute to the overall heterogeneity and the overall results. Two studies were identified as problematic (Turner et al., 2013; Ell et al., 2011). Removing these outlying results reduced effect sizes for all three CV markers: $r = 0.17$, 95% CI [0.08, 0.26], $p < .01$, for CTI, $r = 0.17$, 95% CI [0.09, 0.26], $p < .01$, for CO, and $r = -0.16$, 95% CI [-0.24, -0.09], $p < .01$ for TPR. It also reduced the heterogeneity substantially to a non-significant level of Q statistics CTI $Q(13) = 20.54$, $p = .08$, CO $Q(14) = 21.10$, $p = .10$, and TPR $Q(14) = 16.14$, $p = .31$. The remaining heterogeneity was moderate or small for CTI ($I^2 = 36.31$), CO ($I^2 = 32.44$), and (TPR $I^2 = 14.30$).

3.2. Publication bias analyses

We found indications of publication bias for all of the CV markers. Egger's regression test was statistically significant for CTI ($t = 2.46$, $p < .01$), CO ($t = 1.96$, $p < .05$), and TPR ($t = -2.47$, $p < .01$). Therefore, we recalculated the mean effect sizes with missing studies filled using the Trim-and-Fill method (see Fig. 3). We imputed the effects of four missing studies for CTI, and the effect size was reduced to $r = 0.10$, 5% CI [0.01–0.21]. Three studies were imputed for CO, and the adjusted effect size was $r = 0.14$, 95% CI [0.05–0.22]. Four studies were imputed for TPR, and the recalculated effect size was $r = -0.13$, 95% CI [-0.20, -0.06].

3.3. Moderator analyses

The type of performance (behavioral vs. cognitive), the metabolic engagement level and measurement method did not moderate the relationship between CTI, CO, TPR and the level of performance (Table 2). However, the researcher decision on applying the manipulation to change individuals motivational states (yes/no) was a significant moderator for TPR $Q(1) = 4.53$, $p = .03$, and CTI $Q(1) = 9.04$, $p < .01$, but not for the CO $Q(1) = 1.89$, $p = .17$. The relationship was significantly higher for non-experimental studies ($r = -0.25$ for TPR, $r = 0.24$ for CTI) compared to experiments ($r = -0.09$ for TPR, $r = 0.03$ for CTI).

4. Discussion

Individuals who maintain challenge motivation are more likely to achieve critical life outcomes (see Blascovich, 2008, for a review). One of the hypothesized reasons why challenge evaluations are beneficial pertains to favorable physiological responses to challenge (e.g., increased adrenaline secretion that provides high cardiac efficiency) and negative responses to threat (e.g., impeded blood flow to tissues and decreased venous flow back to the heart). In the current study, we performed analyses that tested whether the effects of CV markers on successful performance that are reported in the literature are robust and unbiased. We observed that some studies that supported the challenge and threat hypothesis had shown exaggerated effects compared to other studies. Furthermore, we found statistical evidence that studies reporting weaker effects are under-represented in the literature. However, even when controlling for these biases, the association between the level of performance and CV markers of challenge and threat was significant. This is an argument for the validity of the biopsychosocial model in the prediction of performance (Blascovich, 2008; Seery, 2013). Yet, the effects that we observed were small, with most of the variance in performance unexplained. This finding is a caveat for the model and its practical utility.

Increases in CO and decreases in TPR were systematically related to superior performance. This finding corroborates the primary physiological assumption of the biopsychosocial model; that is, the challenge and threat physiological changes are related to meaningful coping outcomes. However, the small sizes of these effects pose a question about whether the effects (statistical significance) translate into

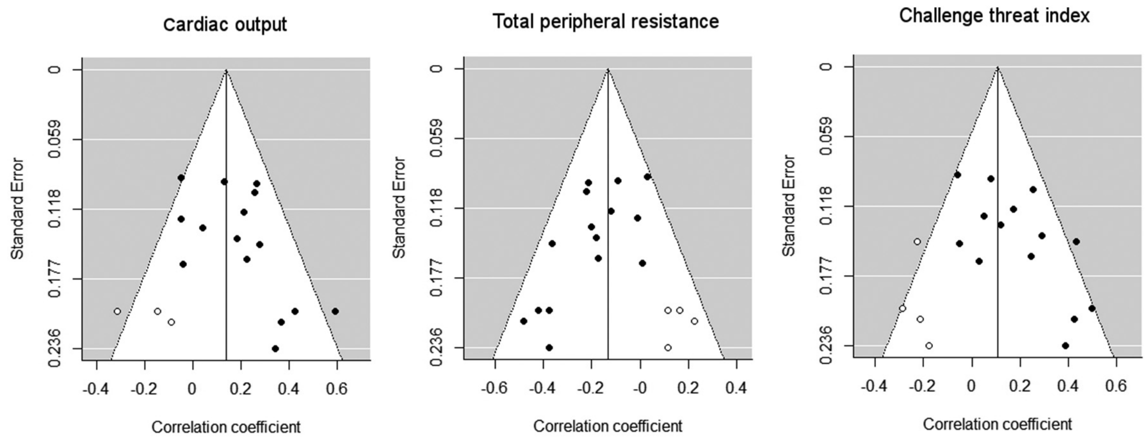

Fig. 3. Funnel plots for CV markers of challenge/threat. Black dots = studies included in the meta-analysis. White dots = studies "filled" based on the trim-and-fill method estimation.

meaningful behavioral differences that are likely to accumulate over time (psychological significance). This questions if the relationship between CV responses and performance might be modeled in a way that explains more variance. However, it is also likely that results from the use of non-invasive methods of CV measurement are suppressed by their limited capacity to reflect the actual hemodynamic processes (Dyson et al., 2010; Shibasaki et al., 2010).

Of the CV indexes, CTI displayed the lowest effect size. CTI performed relatively poorer, by 30–40%, when compared to the raw indexes of CO and TPR. This is an argument against its utility in the context of performance. This difference might result from the derivative nature of this index; that is, CTI results from transformations such as standardizing two different variables and adding them along with their measurement error. Another problem with the CTI is that it seems to have no direct physiological parallel in any specific physiological process. Alongside our empirical arguments, these conceptual arguments might suggest that measures such as CO and TPR that are directly related to specific physiological processes offer a higher predictive accuracy.

We found that for studies with an experimental manipulation the relationship between TPR and CTI (but not CO) and performance was smaller than for non-experimental studies. This suggests meaningful differences between these two research designs. These moderating effects might result from the interference of manipulation with naturally occurring appraisals and physiological responses. Yet, other differences between the experimental and non-experimental studies that were not accounted for might be responsible for these moderating effects.

The moderator analysis indicated that the association of CO and TPR with the level of performance did not depend on the level of engagement. HR and PEP did not moderate this relation significantly. In line with the biopsychosocial model, increases in HR and PEP from the baseline are common across the challenge and threat continuum, whereas they are associated with higher task engagement observed in larger changes (Seery, 2011). This supports the assumption of the BPS model that challenge and threat do not differ across the level of engagement. We also noticed no differences across task domains and measurements methods. For physical and cognitive tasks, the relationship between CO, TPR, and successful performance was similar. These findings suggest that the model can be applied to different contexts of life.

We found two kinds of evidence that the literature regarding challenge and threat and performance is somewhat biased towards the positive. First, we observed that some studies reported effects that were above statistical expectations. This suggests that the distribution of effects for the CV markers might be bimodal with most effects within a low effects range and some within a higher range. Researchers might address this hypothesis in further studies that might replicate these outlying findings (Turner et al., 2013; Ell et al., 2011). Second, we found that some studies (16–28%) might be missing. If they do indeed exist, then these papers would report null results or results that were against the theory-based hypotheses. This publication gap might result from authors who decided not to publish all of their findings or they may stem from the decisions of reviewers and journal editors who might be more likely to decide against publication of such findings, or they may be a combination of both (Franco et al., 2014; Rosenthal, 1979). It is, therefore, imperative for the integrity of the psychophysiological science that both processes are minimized.

This study has several limitations. First, with our focus on psychophysiology, we accounted for the physiological markers of challenge and threat rather than the self-report of challenge and threat. Further studies might try to extend these findings and test the robustness of the association between cognitive evaluations, physiological responses, and behavioral outcomes. However, this is a problematic aim for a meta-analysis given a high diversity of methods to measure self-reported challenge and threat which increases homogeneity between indicators (Field and Gillett, 2010). The preferred strategy was to use validated

Table 2
Moderators of the relationship between cardiovascular predictors of challenge and threat (X) and level of performance (Y).

	HR		PEP		Performance type		Measurement method		Research design	
	Q (1)	*p.h*	Q (1)	*p.h*	Q (1)	*p.h*	Q (1)	*p.h*	Q (1)	*p.h*
CO	0.06	0.80	0.72	0.40	1.11	0.29	–	–	1.89	0.17
TPR	0.19	0.66	0.76	0.38	0.85	0.31	1.21	0.27	4.53	0.03
CTI	0.18	0.67	0.30	0.58	0.03	0.86	1.84	0.17	9.04	0.001

CO = cardiac output, TPR = total peripheral resistance, CTI = Challenge-Threat Index, HR = heart rate, PEP = pre-ejection period. Performance type coded 0 = behavioral, 1 = cognitive, Measurement methods coded as 0 = discrete, 1 = continuous. Research design coded as 0 = non-experimental, 1 = experimental; p.h = probability of Q given no true differences between effect sizes.

physiological markers of challenge and threat with the same methods of measurement. Second, all investigations of challenge and threat have been tested with samples of young adults. Thus, the generalizability of our findings is limited to this age group. More studies are needed to address the robustness of the biopsychosocial model across the life-span because cardiovascular efficiency changes with age (Mitchell et al., 2004). Consequently, little is known about whether or not the physiological benefits of challenge also facilitate behavioral outcomes in older age.

In conclusion, we have provided new evidence for the significance of CO, TPR, and, to a lesser extent, CTI in predicting successful performance. These findings are an essential contribution to the literature because they document the significance of this evidence and they also present its limitations. Our understanding of challenge and threat would benefit from further studies on more diverse populations (e.g., seniors), in addition to a less selective publication process that would allow dissemination of psychophysiological findings, whether they rejected the null hypotheses or not.

Declarations of interest

None.

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Załącznik 2

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Social challenge and threat predict performance and cardiovascular responses during competitive video gaming

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ABSTRACT

Individuals tend to compare themselves with others, and the results of these self-evaluations influence subsequent performance. When individuals perceive an advantage over their rivals (challenge-type response), they achieve higher levels of performance. According to the biopsychosocial model of challenge and threat, benefits of favourable appraisals are partly mediated by cardiovascular efficiency, which is increased by challenge and decreased by threat evaluations. In this study, we tested whether the biopsychosocial model can be extended to predict behavioural outcomes in esports. We expected that challenge-type evaluations would increase performance compared to threat-type evaluations. Eighty-two men were assigned to a challenge or threat group and completed three rounds of Counter-Strike: Global Offensive – a video game popular in esports. Individuals with the highest scores were awarded cash prizes. Cardiovascular markers of challenge and threat, cognitive appraisals, and game scores were recorded. We manipulated the social challenge and social threat evaluation by informing participants that their performance in the initial round was superior (challenge) or inferior (threat) compared with other gamers. We found that individuals with more gaming experience, believed they were better than other gamers, had higher heart rate and, in turn, achieved higher scores. These effects were related to initial situational appraisal at the baseline and were not boosted by feedback provided during the actual performance. These results are the first to document that social comparisons among gamers are accurate in the prediction of future physiological and behavioural outcomes. Furthermore, these findings emphasize that physiological responses mediate relationships between action-related cognitions and performance.

1. Introduction

Thinking about other people in relation to the self is a core process in human social information processing (Festinger, 1954; Mussweiler, 2003). While comparing, individuals seek similarities and differences to adjust their self-evaluations, affect, and behaviour. In upward comparisons, the comparison standard (e.g., another competitor) is better off than the comparer. In downward comparisons, people focus on individuals with fewer resources, e.g., competitors with lower skills. Social comparisons influence individuals' emotions and well-being (Jordan et al., 2011), self-esteem (Vogel, Rose, Roberts, & Eckles, 2014), performance outcomes (Christy & Fox, 2014), and performance satisfaction (Gächter & Thöni, 2010).

Comparing with others is particularly important when people compete with each other in pursuit of the same valuable goal. When people see that they have an advantage over others a challenge response is initiated that engages cognitive (challenge evaluation), physiological (e.g., cardiovascular), and behavioral systems (e.g., motor system) (Blascovich, 2008). Individuals who perceive their advantage over others are motivated to invest resources because this effort is likely to generate a profit. Consequently, challenged individuals are more likely to succeed (Mendes, Blascovich, Major, & Seery, 2001; Scheepers, de Wit, Ellemers, & Sassenberg, 2012). In contrast, when people see that they are less resourceful, a threat response is initiated, which is oriented towards the minimization of losses and unnecessary expenditure of resources. Individuals who perceive their disadvantage over others can withdraw to avoid the unprofitable investment of resources (Blascovich, 2008). Thus, the level of performance is decreased. Of the processes that explain the link between action-oriented self-cognitions and behavioral outcomes, cardiovascular functions has received considerable attention resulting in the formulation of the biopsychosocial model of challenge and threat (Blascovich, 2008; Seery, 2011; Seery, 2013). Above all, the facilitative effect of challenge on performance has been partially explained by increased cardiac efficiency observed during performance of challenged individuals (Behnke & Kaczmarek, 2018).

Several studies have documented how evaluating the situation as a challenge or threat influence performance (e.g., Moore, Vine, Wilson, & Freeman, 2012; Turner et al., 2013). However, a recent meta-analysis revealed weaknesses in the challenge–threat literature (Blascovich, 2008; Seery, 2013), such as reduced support for the biopsychosocial model from experimental evidence where the levels of challenge and threat were manipulated (Behnke & Kaczmarek, 2018). This is important because experiments provide the most powerful design for testing causal hypotheses (Chambliss & Schutt, 2018). Causality inferences are justified when there is an empirical association between

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variables, the temporal priority of the independent variable, and the risk of spurious effects is minimized. Understanding causality informs how to develop efficient interventions that improve performance (Michie, Van Stralen, & West, 2011).

Moreover, few studies in the biopsychosocial model literature have accounted for situations where research participants performed activities central to their interests, e.g., initiated in their leisure time (Moore, Vine, Wilson, & Freeman, 2014; Vine et al., 2015). Studying self-selected individuals is essential because it provides high motivational context, which is necessary for the challenge and threat effects to occur (Blascovich, 2008). High level of task-related motivation is important because individuals must recognize a valuable goal before they take the effort of evaluating whether they have sufficient resources to achieve this goal (challenge) or whether they have deficits in resources and the goal is unlikely to be achieved (threat). Without a meaningful and stimulating goal, neither challenge nor threat occurs (Seery, 2013).

Finally, previous studies on the biopsychosocial model examined how pre-performance physiological changes affect performance rather than physiological function during the actual performance. Noteworthy, some authors have addressed the need to account for challenge and threat physiological processes during the performance (Arthur, Wilson, Moore, Wylie, & Vine, 2019). For instance, previous studies indicated robust links between task engagement and physiological function during performance (De Manzano, Theorell, Harmat, & Ullén, 2010; Nakahara, Furuya, Obata, Masuko, & Kinoshita, 2009). Moreover, research documented that intense physical activity does not obscure the psychological effects on physical responses (Nakahara et al., 2009).

To address these limitations, we aimed to examine challenge and threat cognitive and physiological responses in a novel behavioral context of esports performance. Esports is a novel development in the field of sports where gamers compete using video games (Hamari & Sjöblom, 2016). Competitive video gaming allows studying physiological responses with relatively little interference from the onset of motoric activity. Thus, we organized an esports tournament to account for the effects of social comparisons among gamers.

1.1. Challenge and threat states

Individuals that are motivated to achieve a goal estimate their current resources which are necessary to succeed (e.g., skills, knowledge, and abilities) relative to situational demands (e.g., danger, uncertainty, and required effort) (Lazarus & Folkman, 1984). According to the biopsychosocial model of challenge and threat, when individuals evaluate their resources as sufficient to overcome the situational demands, they experience the challenge state (Blascovich, 2008). On the other hand, threat state appears when situational demands exceed individuals' resources (Blascovich, 2008). Challenge and threat evaluations are two opposing evaluations that reflect the abundance vs. the shortage of resources. Several factors determine resources/demands evaluations during the performance, including changes in task difficulty (Fonseca, Blascovich, & Garcia-Marques, 2014), win and lose possibilities (Seery, Weisbuch, & Blascovich, 2009), self-esteem (Seery, Blascovich, Weisbuch, & Vick, 2004), or goal-setting: e.g., performance-approach vs. performance-avoidance goal (Chalabaev, Major, Cury, & Sarrazin, 2009). When two individuals compete with each other in the sporting context, situational demands relate to opponent skills.

Challenge and threat evaluations lead to a cascade of physiological responses (Blascovich, 2008; Seery, 2011). Four measures of cardiovascular reactivity were used within the challenge and threat paradigm: heart rate (HR), pre-ejection period (PEP; time in milliseconds in the cardiac cycle from initiation of ventricular depolarization to opening of the aortic valve and ejection of blood), cardiac output (CO; the amount of blood in litres pumped by the heart per minute), and total peripheral resistance (TPR; an index of net constriction vs dilation in the arterial system; Blascovich, 2008). During the performance, individuals are motivated to engage their physiological resources necessary for action (Mendes & Park, 2014). This results in increased sympathetic activation in the autonomous nervous system, observed in increased HR and shortened PEP (Seery, 2011). Thus, higher HR and PEP reactivity are interpreted as indicative of stronger motivational intensity. This initial physiological response is further modulated by individuals resources/demands evaluations that initiated cardiovascular challenge and threat response. Cardiovascular challenge response is characterized by activation of the sympathetic-adrenal medullary system, which leads to the release of adrenaline into the bloodstream. Consequently, vasodilatation occurs (widening of blood vessels), which along with higher HR, results in increased CO and decreased TPR (Brownley, Hurwitz, & Schneiderman, 2000). In contrast, threat evaluation inhibits the release of adrenaline and instead releases cortisol that leads to vasoconstriction (narrowing of blood vessels). It produces less efficient blood flow characterized by little or no change in CO and an increase in TPR (Seery, 2011).

The challenge and threat framework has become one of the leading theoretical models for psychophysiological responses related to motivated performance (Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004; Seery et al., 2009; Turner, Jones, Sheffield, & Cross, 2012). The facilitating effects of experiencing challenge rather than threat have been demonstrated in several areas, including learning new skills (Moore et al., 2014), solving cognitive tasks (Scheepers, 2009), negotiating prices (Scheepers et al., 2012), or practicing sports, e.g., playing golf (Moore et al., 2012). A recent meta-analysis supported the facilitative role of the challenge type cardiovascular response linking it with superior performance results (Behnke & Kaczmarek, 2018).

1.2. Esports

Esports is a form of competition that uses video games (Bányai, Griffiths, Király, & Demetrovics, 2019; Hamari & Sjöblom, 2016; Trotman, Williams, Quinton, & van Zanten, 2018). For instance, gamers compete in esports with each other by controlling avatars in a video game world. Esports is a recent development in the field of sports. In order to be considered sports, an activity must meet following criteria: 1) include play (voluntary, intrinsically motivated activity), 2) be organized (governed by rules), 3) include competition, 4) be comprised of skills (not chance), 5) include physical skills—skilful and strategic use of one's body, 6) have a broad audience, and 7) have achieved institutional stability where social institutions have rules which regulate it and stabilize as an important social practice (Gutmann, 2004; Jenny, Manning, Keiper, & Olrich, 2017; Suits, 2007). Esports meets all of the criteria (Jenny et al., 2017; Jonasson & Thiborg, 2010).

Esports is a relatively new social phenomenon with increasing popularity reflected in regular professional leagues (i.e., Electronic Sports League) and tournaments (i.e., Intel Extreme Masters, World Champions, The International). The events are organized by the international esports federations (i.e., International Esports Federation, IeSF) and are watched by hundreds of millions of viewers (Esports Charts, 2019; Hutchins, 2008; Wagner, 2006). People practicing esports are called gamers or pro-gamers in the case of professionals (Taylor, 2012). The average gamer is between 15 and 25 years old and practices approximately 20 h per week (Müller-Lietzkow, 2006). Competitive video gaming involves psychological processes that are characteristic of other sports disciplines, such as quick and accurate decision-making, focused attention, emotion regulation, and extensive game knowledge (Hilvoorde & Pot, 2016; Himmelstein, Liu, & Shapiro, 2017; Ravaja, Saari, Salminen, Laarni, & Kallinen, 2006). Additionally, due to its competitive environment, esports also involves highly motivated individuals (Przybylski, Ryan, & Rigby, 2009). However, there are also meaningful differences in esports performance compared with real-world competitions that are of particular interest to social psychophysiology.

First, during esports, gamers perform in a seated position with most of the physical activity executed in the digital world of the game. It raises a unique situation, where psychophysiological processes can be observed with relatively little interference from the onset of motoric activity. This allows checking whether the conclusions concerning the pre-performance period may be extended to the actual competition. Second, the use of computers and video games allows for the testing of individuals in carefully controlled and manipulated conditions. For instance, gamers can compete against computer-controlled avatars which provide fully standardized and replicable testing conditions – a situation that is not likely to occur in real-world competitions. In summary, research on esports allows testing integrative, multilayer models that account for the role of psychological factors in the course of performance. However, only a few studies have been carried out on esports performance (e.g., Drachen et al., 2014; Rambusch, Jakobsson, & Pargman, 2007; Ravaja, Turpeinen, Saari, Puttonen, & Keltikangas-Järvinen, 2008; Trotman et al., 2018).

1.3. Present study

We aimed to adopt a novel esports research design to examine how social challenge and threat influence gaming outcomes and whether psychophysiological factors may explain these effects. Based on the biopsychosocial model of challenge and threat (Blascovich, 2008), we predicted that a challenge-type evaluation (participants reporting high personal resources relative to situational demands) would be related to superior performance (game score) compared to threat-type evaluation (participants reporting low personal resources relative to situational demands). We expected that individuals who are more challenged during the competition would be more successful later compared with threatened individuals. Finally, we expected that the effects of the challenge and threat evaluation on behaviour (game score) would be mediated by increases in CO, a physiological onset of challenge and threat evaluation indicative of increased cardiovascular efficiency (increased blood flow through the body) (Seery, 2011). We controlled for HR and PEP as physiological indexes of task engagement mediated by sympathetic activation (increased HR and shorter PEP) or parasympathetic withdrawal (increased HR). We organized an esports tournament, that served as a motivated performance context that would attract motivated gamers. The biopsychosocial model of challenge and threat assumes that challenge/threat evaluation occurs when an individual is motivated to perform well (Blascovich, 2008). Thus, we aimed to motivate participants to their peak performance by providing an additional incentive, i.e., prize money in a tournament. Furthermore, by organizing a tournament we provided an ecologically valid context representative for sports activity rather than casual leisure time gaming.

2. Method

2.1. Participants

Participants were 82 *Counter-Strike: Global Offensive* (*CS: GO;* Valve Corp., USA) gamers between the ages of 18 and 31 years ($M = 19.47$, $SD = 2.48$). A power analysis using G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009) indicated that a sample size of 82 participants allowed the detection of moderate effect sizes of $f = 0.15$ for multiple linear regression with up to two predictors and power of .80. We recruited gamers via a Facebook advertisement targeted at *CS: GO* gamers. Of the participants, 72 (88%) were recreational gamers, 7 (8%) were non-professional esports gamers (competing in local or online tournaments), and three (4%) gamers did not report their status. Participants played *CS: GO* systematically, playing form 1 h to 40 h 15.72 h per week on average ($SD = 8.53$). Gamers had normal or corrected vision and no known family history of cardiovascular or respiratory disease. Participants were asked to reschedule if they experienced illness or a significant adverse life event. We asked participants to refrain from vigorous exercise, food, and caffeine for 2 h before testing. We introduced the above restrictions to eliminate factors that might affect cardiovascular functions or usual gaming performance examined in this study. Participants were tested individually and received a voucher for a cinema ticket for participation in the study. To increase the motivation to participate in the study, we announced cash prizes for the top three gamers ($60, $30, and $15 respectively). Top gamers received their prizes once the research has been completed. Each participant provided written informed consent. The institutional ethics committee approved the study.

2.2. Measures

2.2.1. Physiological measures

Cardiovascular challenge and threat response. Responses on the cardiovascular challenge – threat dimension were operationalized as responses in HR and PEP followed by responses in CO. Increased HR reflects sympathetic activation and parasympathetic withdrawal in the autonomous nervous system (Blascovich, Vanman, Mendes, & Dickerson, 2011). Shorter PEP reflects sympathetic activation. These responses (increased HR and shorter PEP) are characteristic of physiological readiness to a motivated performance (Blascovich, 2008). Resources/demands evaluations lead to changes in CO that reflect the volume of blood being pumped by the heart per minute. Challenge response is characterized by increased CO, and threat response is characterized by decreased CO (Blascovich, 2008; Seery, 2011). Challenge and threat cardiovascular response is also reflected in changes in total peripheral resistance (TPR) that indicates resistance that must be overcome to push blood through the circulatory system. CO and TPR are highly inversely correlated (Seery, Weisbuch, Hetenyi, & Blascovich, 2010). We were not able to calculate TPR because we did not measure blood pressure while participants used both hands to control the keyboard and mouse intensely during the game.

Cardiovascular biosignals were recorded continuously and noninvasively with the Vrije Universiteit Ambulatory Monitoring System (VU-AMS, the Netherlands) following psychophysiological guidelines (Sherwood et al., 1990). Impedance cardiography (ICG) and electrocardiography (ECG) recordings provided continuous measures of cardiac action and hemodynamic levels. The VU-AMS recorded ECG pregelled AgCl electrodes (Kendall Abro, H98SG) placed in a Lead II configuration (on the right collar bone and left side of the chest). Impedance cardiography was recorded with pre-gelled AgCl electrodes (Kendall Abro, H98SG) with a four-spot electrode array (Houtveen, Groot, & De Geus, 2005; Sherwood et al., 1990). The first electrode was placed over the sternum between the two collarbones, the second over the tip of the xiphoid complex of the sternum, the third on the back over cervical vertebra C4, and the fourth between thorax vertebras T8 and T9. Based on ICG and ECG signals, we calculated HR, PEP, and CO. After the VU-AMS Data, Analysis & Management Software (VU-DAMS 3.0) detected R-peaks in the ECG, we visually checked and adjusted all R-peak markers when necessary. We scored CO and PEP from 30-s ensemble averages of the ICG using the validated VU-AMS interactive scoring software (Kupper, Willemsen, Boomsma, & De Geus, 2006). Scoring was performed blind to other participant data. We used averaged measures from the Match1 and Match 2 period. Next, we calculated reactivity scores for HR, PEP, and CO (Christenfeld, Glynn, & Gerin, 2000), where the score of the last 2 min of baseline was subtracted from the Match 1 and Match 2. This calculation is mathematically equivalent to computing the area between the reactivity curve and the resting level. Using difference scores is a standard strategy for the study of autonomic responses to psychological factors (e.g., Monfort et al., 2014).

2.2.2. Performance

Participants played *Counter Strike: Global Offensive* (*CS: GO)*, which is a multiplayer team-based first-person shooter where two teams compete against each other in simulated military combat. *CS: GO* is the leading game in the esports team-play category. It is also a popular leisure activity that engages up to 600,000 daily active gamers worldwide (Steam & Game stats, 2019). In this game, individuals from two teams with opposing motives: counter-terrorists vs. terrorists. The mission of the counter-terrorists is to disarm explosives planted by the terrorists or eliminate all member of the opposing team. Players are eliminated from the match when their avatars suffer fatal damages received from other gamers. In *CS: GO*, gamers compete online against other gamers or offline against computer-controlled characters.

To standardize conditions across participants, each participant competed in a deathmatch mode on the Dust II map against computer-controlled avatars (bots) set at the maximum difficulty level (expert). The game system calculated each match score by multiplying the points for eliminating each enemy bot by the weapon difficulty level. Higher scores indicated better performance. To determine whether these settings were sensitive to psychological influences, we calculated correlation of scores between Match 1 and Match 2 as a measure of testing reliability and the coefficient of variation, i.e., ratio of the standard deviation to the mean (Currell & Jeukendrup, 2008). The coefficient of variation was acceptable for both matches, 21% for Match 1 and 19% for Match 2. Moreover, a strong correlation between scores in Match 1 and Match 2, $r = 0.56$, $p < .05$, indicated that the gaming outcomes were not due to chance and reflected individual gaming skills and efforts.

2.2.3. Challenge and threat evaluation

We used a validated approach to the measurement of challenge and threat evaluations conceptualized as the difference in resources (action-oriented self-evaluation) and demands (evaluation of others) (Seery, 2011; Tomaka, Blascovich, Kelsey, & Leitten, 1993). We asked participants how they rated their level of *CS: GO* skills and what they thought about the skills of other participants in the contest. Participants used a 7-point scale ranging from 1 ('extremely low skills') to 7 ('extremely high skills'). After subtracting demands for winning the competition (other gamers' skill levels) from resources (own skill level), the evaluation score ranged from −6 to +6 with positive scores reflecting high social challenge and negative scores reflecting high social threat.

2.2.4. Gaming experience

CS: GO gaming experience was conceptualized as the total time spent playing the game. Gamers were asked to report total hours played that was counted by the gaming system (Steam Library; Valve Corp., USA). Gamers reported CS: GO gaming experience from 75 to 3900 h ($M = 1008$ h, $SD = 556.67$) (Steam Library; Valve Corp., USA).

2.3. Challenge and threat manipulation

Participants were randomly assigned to the social challenge or the social threat group. We manipulated challenge and threat evaluations through fake feedback that we provided to the participants. The instructions were adapted from previous research (e.g., Feinberg & Aiello, 2010; Moore et al., 2012). For example, the challenge instructions facilitated downward social comparison; i.e., we informed participants that they performed better than 83% of other gamers. To maintain task engagement, both groups received instructions emphasizing the importance of Match 2 of the tournament and we also prompted rewards for the highest-scoring participants.

> You have just finished the first round of the tournament. Your score is [the real score was displayed here]. You achieved a result higher than 83% of the tournament participants. Now, the second round will take place. This is the most important part of the study, so we ask you to do your best and improve your score from the previous round. The top three performers will be awarded cash prizes of $60, $25, and $15, respectively. Think of the upcoming round as a challenge to be met and overcome. Research has shown that the best gamers improve their scores in final rounds. Think of yourself as someone capable of meeting that challenge and do your very best. With these instructions and the belief that you are able to win the tournament in mind, please wait for the second round.

For the threat elicitation, we used the following instruction:

> You have just finished the first round of the competition. Your score is [the real score was displayed here]. You achieved a result lower than 83% of the tournament participants. Now, the second round will take place. This is the most important part of the study, so we ask you to do your best and improve your score from the previous round. The upcoming round can be a difficult and frustrating task, and you may not improve your scores from the first round. Research has shown that most gamers do not improve their scores in final rounds. Although the task may seem difficult, try your best. With these instructions in mind, please wait for the second round.

2.4. Procedure

Participants were tested individually in a sound-attenuated and air-conditioned room. Upon arrival in the lab, participants provided informed consent, and the researcher applied sensors to obtain cardiovascular measurements. After the experimenter left the testing room, participants received instructions and responded via a PC with a 23-inch screen located in their cubicle. Participants reported demographics and sat quietly for the next 5 min.

Participants were given 10 min for free play as a warm-up (Fig. 1). They reported how they perceived the upcoming match regarding demands and resources (challenge and threat status). After 2 min of resting, they completed the first round of the esports competition (10 min) and received fake feedback regarding their inferior or superior performances relative to other competitors. They re-evaluated their resources, rested for 2 min, and completed the second round of the competition. Upon completion, participants were debriefed and received cinema vouchers for their participation. A few weeks later, the tournament winners received their awards.

2.5. Analytical strategy

2.5.1. Preliminary analyses

Before testing hypotheses, we checked the validity of the study procedure (did the performance produce meaningful HR response indicative of motivational intensity), and the experimental manipulation (did the performance feedback produce changes in the challenge and threat evaluation).

Motivated performance. First, we tested whether gamers attending esports competition were physiologically engaged to recognize this situation as motivated performance. As an indicator of behavioural motivation intensity and action readiness, we tested whether individuals increased their HR levels (Moore et al., 2014). For this purpose, we used a repeated measures analysis of variance (ANOVA). We tested whether participants increased from main baseline to pre-match baseline in HR and PEP.

Participants self-selected to participate in the tournament. Thus, we expected they might already be highly motivated and aroused at the baseline, and further increase their motivation and arousal during the competition. Most performers tend to increase their HR before the performance as indicated by research among bikers (Mateo, Blasco-Lafarga, Martínez-Navarro, Guzmán, & Zabala, 2012), swimmers (Cervantes Blásquez, Rodas-Font, & Capdevila Ortís, 2009), or musicians (Abel & Larkin, 1990). Therefore, we tested absolute HR levels at pre-match baseline against the normative resting HR of 64.80 beats per minute reported in a meta-analysis (Nunan, Sandercock, & Brodie, 2010). We reported the effect size of this difference using Cohen's *d*.

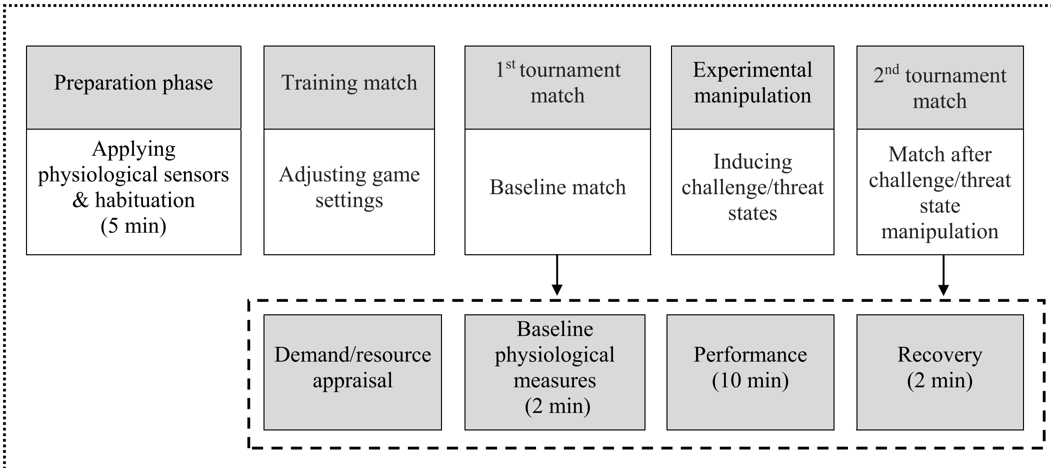

Fig. 1. Study procedure.
Note. Dotted frame represent study procedure, dashed frame represent repeated procedure of tournament matches.

Table 1
Correlation matrix and descriptive statistics.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Score T1										
2. Score T2	.56**									
3. Evaluation T1	.32**	.21								
4. Evaluation T2	.30**	.19	.32**							
5. CO T1	.02	-.02	.11	-.13						
6. CO T2	.15	.12	.14	-.06	.79**					
7. HR T1	.34**	.19	.40**	.22*	.40**	.35**				
8. HR T2	.23*	.19	.36**	.25*	.32**	.37**	.88**			
9. PEP T1	-.05	.02	-.12	-.05	-.38**	-.26*	-.37**	-.24*		
10. PEP T2	.12	.14	-.11	.13	.00	.01	-.18	-.13	.43**	
11. Group	.10	.05	.37**	−0.07	−0.07	−0.01	0.08	0.01	0.11	−0.19
M	459.16	477.87	−0.57	−0.49	−0.60	−1.15	0.01	−0.06	−2.83	−1.60
SD	96.51	90.21	1.52	2.09	2.65	2.75	6.31	7.34	11.54	13.33

$^*p < .05$. $^{**}p < .01$.
Note. Descriptive statistics present change scores relative to baseline. Group coded as threat = 0, challenge = 1. T1 and T2 = measurement for match 1 and match 2, Evaluation = cognitive appraisal of resources vs situational demands. CO = cardiac output, HR = heart rate, PEP = pre-ejection period.

Manipulation check. To support the effectiveness of experimental manipulation, we tested whether there was an interaction between feedback (superior vs. inferior results) and time (pre-test vs. post-test) in their effect on the challenge and threat evaluation. We expected that individuals would experience increases in challenge and threat evaluation after receiving feedback about their superior performance and decreases after receiving feedback about their inferior performance.

2.5.2. Main analysis

We tested how the challenge and threat evaluations affect the performance outcomes and physiological responses during the gameplay. Main hypotheses were tested using a path analytical approach with maximum likelihood mean, and variance adjusted estimator (MLM) performed using mPlus 7.2 (Muthen & Muthen, 2012). This technique allows the testing of specific direct and indirect pathways between experimental factors, moderators, and outcomes. The number of participants was acceptable for small sample size path analysis (Bentler, 2007). The hypotheses can be considered supported if the model fits the data well – i.e., RMSEA < 0.06, CFI > 0.95, and SRMR < 0.08 (Hu & Bentler, 1999) – and the regression coefficients for hypothesized direct and indirect effects are significant.

3. Results

3.1. Preliminary analysis

Motivated performance. We compared absolute levels of HR during baseline ($M = 87.62$, $SD = 11.87$) and before Match 1 ($M = 87.47$ $SD = 11.02$). A repeated measures ANOVA showed that participants did not further increase their HR between baseline and before Match 1, $F(1, 81) = 0.09$, $p = .77$, $\eta^2 = 0.001$. Participants did not decrease their PEP either, $F(1, 81) = 2.41$, $p = .12$, $\eta^2 = 0.03$, when comparing their baseline ($M = 105.55$, $SD = 17.27$) with pre-game levels in Match 1 ($M = 104.15$ $SD = 16.46$). However, gamers displayed higher absolute HR at baseline when compared to normative resting HR ($M = 64.80$, $SD = 6.67$), $t\ (81) = 17.40$, $p < .01$, $d = 3.40$ (Nunan et al., 2010).

Manipulation check. Supporting the validity of experimental manipulation, we found a significant interaction between the experimental condition and time in their effect on challenge and threat evaluation, $F\ (1, 81) = 22.47$, $p < .01$, $\eta^2 = 0.22$. After receiving positive feedback, the challenge and threat evaluation significantly increased, $F\ (1, 40) = 9.89$, $p < .01$, $\eta^2 = 0.21$, and after negative feedback, the evaluation significantly decreased $F\ (1, 40) = 12.87$, $p < .01$, $\eta^2 = 0.25$.

3.2. Main analysis

Descriptive statistics and correlations between study variables are

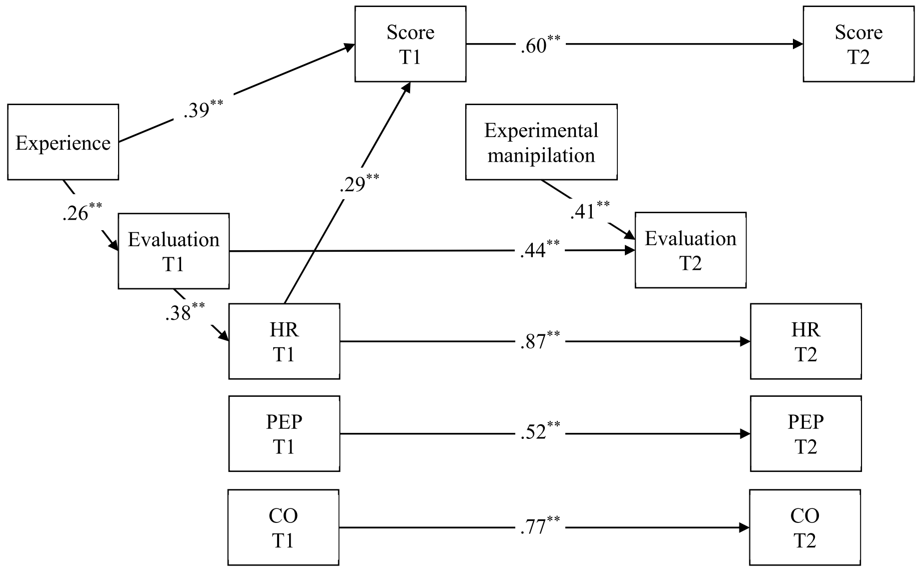

Fig. 2. Final model
Note. T1 and T2 = measurement for match 1 and match 2; Evaluation = cognitive appraisal of resources vs. situational demands. HR = heart rate, CO = cardiac output, PEP = pre-ejection period, Score = game results.

presented in Table 1. The final model fit the data well, χ^2 (42) = 51.75, p = .14, RMSEA = 0.06, 90% CI [0.00, 0.12], SRMR = 0.08, CFI = 0.97 (Fig. 2). Non-significant paths had no effect on the model fit, $\Delta\chi^2$ (2) = 3.99, $p > .05$; thus, they were removed.

As expected, more experienced gamers evaluated the game as more challenging and scored higher in Match 1 and Match 2; a significant indirect effect via the Match 1 score, $\beta = 0.23$, $p < .01$ (Fig. 2). Moreover, participants who perceived the upcoming game as a challenge (resources outweigh situational demands) displayed higher HR reactivity compared to individuals who perceived the upcoming game as a threat (situational demands outweigh resources). Thus, higher HR reactivity was also related to higher game scores. We observed an indirect effect of experience on game scores during Match 1 via challenge and threat evaluation and HR, $\beta = 0.03$, $p = .04$. HR reactivity during Match 1 had a direct effect on higher scores and an indirect effect on higher scores in Match 2 via scores in Match 1, $\beta = 0.14$, $p = .03$. Challenge evaluation before Match 1 had an indirect effect on higher scores in Match 1 via increased HR, $\beta = 0.11$, $p = .02$, and in Match 2 via HR reactivity and scores in Match 1, $\beta = 0.06$, $p = .04$.

Individuals who received performance-related superiority feedback felt more challenge during Match 2 compared with individuals who were informed that their performance was worse than that of the majority of contestants. However, this feedback had no consequences for performance and physiological processes. Performance and physiological processes during Match 2 were largely predicted by their initial levels, i.e., auto-regression. CO, as the expected challenge and threat state indicator, was not related to evaluations and game scores. PEP did not correlate with model variables. Finally, pre-performance physiological levels were not predictive in the model.

4. Discussion

In this study, we aimed to examine whether challenge and threat evaluation influenced gamers' performance and whether challenge and threat evaluation was influenced by the provision of situational performance-related feedback. Moreover, we examined whether the influence of cognition on behavioural outcomes was mediated by physiological processes that indicate motivational intensity and challenge and threat cardiovascular response.

The main finding in this study is that individuals who had more gaming experience initially perceived the abundance of personal resources (their skills) relative to demands to win the contest (other gamers' skills) and, in turn, were more successful than individuals who perceived their initial resources as insufficient relative to demands. This relationship occurred for challenge and threat appraisals in Match 1, and indirectly in Match 2. Moreover, challenged individuals mobilized greater physiological resources, as indexed by higher HR, but did not achieve greater cardiac efficiency, as indexed by CO. This might mean that the heart action was faster but the amount of blood circulating in the CV system remained the same. Because CO is the product of HR and stroke volume (the amount of blood ejected from ventricles due to each contraction) (Blascovich et al., 2011), increased HR with no changes in CO suggests that there might have been decreases in stroke volume. Alternatively, increased HR could result from decreased blood pressure via baroreflex response (Heesch, 1999). A broader interpretative framework would be possible if blood pressure measures were available. However, it was not feasible to measure blood pressure in the current setup due to the amount of hand movement in gamers.

We found support for the role of challenge and threat evaluation in predicting desirable outcomes (Gildea, Schneider, & Shebilske, 2007). Although the critical role of favourable self-evaluations in goal-oriented behaviour has been documented in previous theories and studies (e.g., Feinberg & Aiello, 2010; Lazarus & Folkman, 1984; Putwain, Symes, & Wilkinson, 2017), we extended the generalizability of this model to competitive video gaming. The replicative part of this research is essential because several analyses indicate that effects reported in the psychological literature often fail to replicate (Camerer et al., 2018; Open Science Collaboration, 2012; 2015).

We also accounted for physiological responses that complemented and partially explained the link between challenge and threat evaluations and behaviours. In comparison to the approach that examined pre-performance physiological responses, we accounted for changes occurring during the actual performance (e.g., Chalabaev et al., 2009; Ell, Cosley, & McCoy, 2011; Frings, Eskisan, Spada, & Albery, 2015; Mendes, Blascovich, Lickel, & Hunter, 2002; Scholl, Moeller, Scheepers, Nuerk, & Sassenberg, 2017). We observed that more challenged individuals had higher HR, which is suggestive of stronger mobilization of physiological resources (Seery, 2013). Pre-match cognitions and HR activity during the performance were related to higher subsequent scores throughout the whole tournament. Taken together, these findings indicated that the benefits of positive game-related cognitions initiate bodily responses that help achieve higher scores. Moreover, we failed to replicate the pre-performance physiological levels in the prediction of performance outcomes. This might suggest that meaningful cardiovascular influences started or reached significant levels in the performance phase of the study. Thus, challenge and threat response influenced physiological levels during the game rather than while anticipating. Previous studies also indicated that higher HR during performance reflects high task engagement (De Manzano et al., 2010), active rather than passive involvement in activity (Nakahara et al., 2009), or performing rather than rehearsing (Iñesta, Terrados, García, & Pérez, 2008). We believe that this approach contributes to the biopsychosocial model literature by indicating that the physiological levels during performance convey significant information that is related to behavioral outcomes.

Noteworthy, we observed that gamers in this study had higher levels of HR than usual resting levels while anticipating the performance (baseline). One explanation of this effects is that gamers attending our esports event might have been already physiologically aroused and motivated at the baseline, presumably due to the anticipation of the competition. This might indicate that gamers achieved high motivational intensity and physiological engagement before the game and did not further increase throughout the game. Similar findings were observed in previous studies where bikers, swimmers, and instrumentalists displayed increased HR before the performance (Abel & Larkin, 1990; Cervantes Blásquez, Rodas Font, & Capdevila Ortís, 2009; Mateo et al., 2012). There are several reasons why it might be adaptive to be fully physiologically mobilized before the competition rather than initializing mobilization after the competition starts. First, early physiological mobilization is likely to provide immediate availability of physiological resources during the performance (Mendes & Park, 2014). Second, early physiological mobilization (e.g., increased HR) provides more time for arousal reappraisal (Jamieson, Crum, Goyer, Marott, & Akinola, 2018). Individuals have more time to adjust to their arousal before the necessity to allocate their attention to the task rather than changes in the body.

Contrary to expectations, we did not observe CO levels measured before or during the performance as being predictive of better scores. This means that increased blood flow throughout the body resulting from vasodilatation did not facilitate gaming outcomes. This contradicts the biopsychosocial model (Blascovich, 2008) as well as other research that indicated that increased CO facilitates better performance (e.g., Moore et al., 2014; Scholl, et al., 2017; Turner et al., 2013). One explanation of this null effect might pertain to the behavioural specificity of gaming (based on precision movements rather than gross body movements) compared with other forms of behavioural activity that were used to test the biopsychosocial model. However, a meta-analysis revealed that previous studies provided support that CO is equally predictive of successful activity which requires gross body movements (e.g., running) and precision movements (e.g., darts) (Behnke & Kaczmarek, 2018). Some authors emphasize that although the challenge cardiovascular response is usually accompanied by better performance (Blascovich, Mendes, Hunter, Lickel, & Kowai-Bell, 2001), the relationship between challenge CV markers and outcomes can be sometimes related indirectly via psychological mediators such as effort (Scheepers, 2009). Thus, it is not unlikely that other components of the psychophysiological mechanism among *CS: GO* gamers were needed to reconstruct the path between CO and behavioral outcomes. Another explanation might be that *CS: GO* gaming is based on quick planning and decision-making: a type of cognitive activity that is sparsely represented in the biopsychosocial literature. There have been two studies that also found that CO was not predictive of performance levels where participants played golf (Moore et al., 2012) or performed a word-finding task (Scheepers, 2009). Thus, a growing number of studies suggest that there might be some unaccounted moderators for the relationship between CO and behavioural outcomes.

Moreover, the positive feedback had a large facilitating effect, and the negative feedback had a large detrimental effect on the challenge and threat evaluation; yet, this feedback did not further influence physiological responses or performance outcomes. We observed that gamers who received bogus feedback informing them about their advantage over other gamers reported increased resources in comparison to the situation requirements. In contrast, gamers who were informed that they were worse than the majority of other gamers felt more threatened. This indicates that challenge and threat evaluations are sensitive to situational feedback among *CS: GO* gamers. Previous studies also reported the malleability of the stress evaluation (Putwain et al., 2017). In this study, we addressed a social challenge and threat, conceptualized as a situation when winning or losing depends on the performance of other people. This links the current research to the social comparisons literature because social challenge and threat are special cases of challenge and threat evaluations (Gerber, Wheeler, & Suls, 2018). We found that a critical aspect of gamers' performance was easily manipulated by providing upward and downward comparisons. Although we found effects of spontaneous but not manipulated evaluation, some other studies indicated that individuals reap other psychological benefits (e.g., self-esteem) when they contrast themselves with others (Mendes et al., 2001). Above all, encouraging downward social comparisons might be especially facilitative in some circumstances because individuals do not tend to form spontaneous downward social comparisons, even when they feel threatened (Gerber et al., 2018). In contrast, individuals tend to form upward social comparisons – a strategy that may worsen their performance. Hence, this study adds to accumulating evidence that social comparisons are vital for performance regulation (Gerber et al., 2018). Yet, these effects may pertain mostly to initial assessments (primary evaluation) rather than assessments modified in the course of performance: i.e., reappraisal (Lazarus & Folkman, 1984).

This study has practical implications. First, this study suggests that video gamers are less likely to succeed when they maintain inferior social beliefs. We presented that strong beliefs in own skills before the competition may lead to successful performance. This indicates that gamers tend to be accurate at determining their performance level relative to other gamers. Experienced gamers accurately predicted that they would do well and further feedback did not influence their outcomes. This seems to suggest that it is important to develop self-confidence during the training and pre-competition phase as a component of an overall resilience building. For instance, coaches might plan the season schedule to help their athletes to build stronger self-confidence as a distinct component of mental training (Behnke, Tomczak, Kaczmarek, Komar, & Gracz, 2019). Consequently, athletes might be more resistant to misleading threatening information during competitions, i.e., inferiority feedback from the opposing team or fake news related to rivals' excellent shape. It is, however, worth noting that this observation is based on differences in a primary evaluation that was not subject to manipulation and is not based on causal effects. Thus, it is difficult to distinguish to which extent the primary evaluation reflects psychological processes rather than actual differences in skills that individuals might possess based on their previous gaming experience and previous social comparisons. For instance, it would be possible to distinguish between primary situational evaluation and actual differences in gaming experience, if we selected individuals with no experience in multiplayer first-person shooter video games and randomized them into CS:GO training group and a control group first, and then run the study procedure with trained and inexperienced players. Second, we found that more experienced gamers, who displayed higher confidence in their skills, and who eventually achieved higher scores had higher levels of HR. Thus, this study indicates that a stronger physiological response predicts better performance. This observation can be surprising to some individuals who might expect that stress impedes performance and high physiological arousal (e.g., increased HR) indicates a self-regulation failure and predicts adverse outcomes (e.g., Bouton, Mineka, & Barlow, 2001). Thus, findings of our study can serve as a persuasive argument that can counteract such beliefs, i.e., higher arousal predicts better performance. This can contribute to the reappraisal of the arousal method of performance improvement (Jamieson, Mendes, & Nock, 2013; Moore, Vine, Wilson, & Freeman, 2015) and facilitate stress response optimization (Jamieson, Crum, Goyer, Marotta, & Akinola, 2018). Reappraisal arousal involves building a positive attitude towards stress-related physiological responses with a focus on their facilitative effects. Current findings support this notion and can be persuasive in building a mindset that is more resilient to stress and its physiological manifestations.

The study has limitations. First, we studied male gamers due to their predominance among pro-gamers (Entertainment Software Association, 2018; Kim, 2017). Thus, our findings are generalized to male gamers; future studies might indicate whether the results generalize to women. Second, we observed gamers in real-life action, with high muscular tension and rapid motoric activity. This increases the ecological validity of the findings at the cost of measurement precision. Participants' physiological responses to motoric efforts might have interfered with physiological responses to cognitions and emotions that were the primary targets of the study. Third, baseline HR levels in our study were significantly higher than resting HR among healthy individuals (Nunan et al., 2010), and we observed non-significant gaming reactivity relative to the baseline. The reasons for this phenomenon are difficult to determine with the current procedure where we did not collect participants' baseline HR levels before the day of the tournament. Noteworthy, we compared participants' baseline HR against a published normative resting HR – a strategy that might not reflect the right resting HR of the participants. However, our *ad hoc* hypothesis might be that competing individuals were less motivated to down-regulate their arousal. This is a caveat for the interpretation of the results from the perspective of the biopsychosocial model. Further studies might provide more directive informational strategy to guide the participants how to achieve greater relaxation before the performance. Consequently, true resting capacity of the participants might be assessed and accounted for in the analysis of reactivity. Fourth, we did not measure blood pressure and, in turn, we were not able to calculate TPR – a hemodynamic index that is also indicative of challenge and threat physiological response. Measuring blood pressure would have been problematic within the study context because participants used both hands during the game. However, a recent meta-analysis indicated that CO and TPR are equally predictive of performance when used independently, and superior to the use of the combination of CO and TPR (i.e., challenge/threat index) (Behnke & Kaczmarek, 2018). Fifth, we had no control group that received no feedback or neutral feedback. We used a repeated-measures design that had a neutral pre-test, thus we were able to test whether the positive group significantly increased and the negative group significantly decreased their evaluations relative to the neutral initial conditions. A neutral control group would provide additional information regarding spontaneous changes that were likely to occur between T1 and T2 measurements. A control group would serve as a stronger reference point for testing the strength and direction of effects of experimental manipulation. Finally, rather than asking about general cognitions (e.g., "How demanding do you expect the task to be"), we aimed to be specific and ask about the task-related social challenge and threat factors, i.e., how other individuals are perceived in the context of the tournament. Consequently, we were able to pinpoint the social task-related threat and challenge evaluations: the ratio of individual skills relative to the skills of other gamers as a condition for winning the tournament. It limits the interpretation of our findings because the general challenge and threat evaluations (Do I have sufficient resources to win this tournament?) included other factors, e.g., is related to personality traits (Penley & Tomaka, 2002). However, we believe that this approach contributes to the literature by indicating that asking about more specific task-related evaluations provides meaningful findings.

5. Conclusion

The strength of this study is that it is among the most advanced real-life accounts of esports as a novel setting for the examination of phenomena related to social psychophysiology. We sought to add to the current state-of-the-art by accounting for a real-life competitive event (Turner et al., 2012). In this way, we achieved relatively high ecological validity, similar to authentic esports tournaments with prizes (King, Delfabbro, & Griffiths, 2009). Using a multilayer approach, we were able to observe how social cognitions influence performance-related behaviours and how physiological responses mediate these effects.

Declarations of interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.psychsport.2019.101584.

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Załącznik 3

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The Role of Emotions in Esports Performance

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Abstract

Emotions that differ on the approach-avoidance dimension are thought to have different functions. Based on the motivational dimensional model of affect, we expected high-approach tendency (and not valence) to facilitate sports performance in a gaming context. Moreover, we expected the influence of high-approach emotions on performance to be mediated by higher levels of cognitive and physiological challenge as an approach-related response. To test these hypotheses, 241 men completed five matches of a soccer video game FIFA 19. Before each match, approach tendencies and valence were experimentally manipulated by showing films that elicit amusement, enthusiasm, sadness, anger, and neutral states. Approach tendency, challenge/threat evaluations, cardiovascular responses, and game scores were recorded. After watching enthusiastic and amusing videos, gamers displayed stronger approach tendencies, and, in turn, improved performance, compared to negative emotions and neutral conditions. Moreover, enthusiasm produced a stronger approach tendency and promoted better performance than amusement. Elicitation of unpleasant emotions (anger and sadness) had no effect on approach tendencies or gaming-outcomes relative to the neutral conditions. Across all conditions, gamers with higher levels of cognitive and cardiovascular challenge achieved higher scores. These findings indicate that in a gaming context, performance is enhanced by pleasant emotions with high-approach tendencies.

Keywords: pleasant emotions, approach motivation, challenge and threat, enthusiasm, psychophysiology.

The Role of Emotions in Esports Performance

How do preperformance emotions influence sports competition? Prior work has shown that pleasant emotions are often associated with higher levels of performance, whereas unpleasant emotions are often associated with lower levels of performance (Campo et al., 2019; Martinent & Ferrand, 2015; Rathschlag & Memmert, 2015; Uphill & Jones, 2007; Vast et al. 2010). However, emotions are more than just pleasant or unpleasant states; they also often include a motivational tendency to approach or avoid a situation (Gable, & Harmon-Jones, 2010). Considering both dimensions of affect – valence and approach-avoidance tendencies - it is not yet clear which one is responsible for beneficial effects in sports performance. This is not an exhaustive list of affective dimensions that characterize emotional experience (e.g., arousal, attention, certainty, commitment, control, dominance, effort, fairness, identity, obstruction, safety, upswing) (Cowen & Keltner, 2017). We start with valence because it is the most fundamental and well-studied aspect of the emotional experience, and we contrasted it with the motivational tendency that is a rather novel, and not fully explored dimension that might be critical in a performance context (Gable, & Harmon-Jones, 2010). In this investigation, we used the motivational dimensional model of affect (Gable, & Harmon-Jones, 2010) to test the relative contributions of emotions' approach tendency (low/high) and valence (pleasant/ unpleasant) in the context of sports performance.

In particular, we focused on esports, which is a novel context for studying emotions and behavior. Esports is the fastest-growing area in the field of sports, in which individuals compete with one another using video games. Gamers are highly motivated individuals who regularly train to develop their skills and compete (Pedraza-Ramirez et al., 2020). Esports involves psychological processes similar to sports such as accurate decision-making, creative thinking, and in-depth game-related knowledge (Pedraza-Ramirez et al., 2020). Moreover, the development of technology allows esports competition to be carried out entirely online without the need for physical contact between players (e.g., during the COVID-19 lockdown, esport remained one of the very few fully authorized forms of sports competition). Also, in esports, gamers compete in the seated position in front of the screen, which provides an excellent opportunity to examine psychophysiological responses related to performance in the laboratory settings, which are also ecologically valid. In summary, we focus on esports due to its novelty, extremely fast-growing popularity, and its compatibility with psychophysiological laboratory research.

Motivation and Emotion

Emotions are widely believed to help energize and direct behavior (Ekman, 1992; Frijda, 1986), but the precise nature of the differential motivational impact of various emotions is not yet clear. Recent work has demonstrated that high-approach emotions differ from low-approach emotions in several different ways, including their neural correlates (Harmon-Jones et al., 2008), their effects on cognition (Gable & Harmon-Jones, 2008), their peripheral physiology (Kaczmarek, Behnke, Kosakowski et al., 2019; Qin et al., 2019), and their effects on behavior (Fawver et al., 2014; Mouras et al., 2015).

However, despite the research on basic processes, the role of approach tendencies has been understudied in complex phenomena such as sports performance. Theoretical models propose that individuals should benefit from high-approach tendencies while attempting to acquire desired goals by shutting out irrelevant perceptions and cognitions (Gable & Harmon-Jones, 2010). Studies have shown that individuals perform better in cognitive tasks when they display strong approach tendencies under high time pressure (Friedman, & Förster, 2005; Roskes et al., 2011; 2013). However, it is not clear whether approach tendency or valence drove these effects because approach tendencies were induced with positive stimuli, whereas avoidance tendencies with negative stimuli (Friedman, & Förster, 2005; Roskes et al., 2011, 2013).

Blending pleasant and high-approach emotions is possible because motivational tendencies and valence are usually highly correlated, as seen by individuals being more likely to approach situations that elicit pleasant feelings and avoid situations that elicit unpleasant feelings (Cacioppo et al., 1999; Marchewka et al., 2014). However, this hedonic rule does not always apply. Experiencing anger, a generally unpleasant emotion, is related to high-approach tendency to face the stimuli and act to reduce its distressing influence (Carver & Harmon-Jones, 2009). Additionally, positive emotions also differ in terms of the intensity of approach motivational-tendency, such as enthusiasm being a high-approach emotion, whereas amusement or contentment are low-approach emotions (Gable & Harmon-Jones, 2008, 2010).

Motivation, Emotion, and Sports Performance

Emotions are an integral part of sports performance (Hanin, 2007; Robazza, 2006; Uphill & Jones, 2007), but to date, few experimental studies examined how discrete emotions influence sports performance (Davis et al., 2010; Rathschlag & Memmert, 2013, 2015; Woodman et al., 2009) with the exception of anxiety (see Woodman & Hardy, 2003, for the review). The studies have shown that recall of happiness promoted better sprint performance in comparison to neutral and anxiety conditions (Rathschlag & Memmert, 2015). Recalled happiness and anger promoted better performances in strength and vertical jumping tests compared to neutral affect, anxiety, and sadness (Rathschlag & Memmert, 2013). Furthermore, individuals in imagery-evoked anger displayed greater gross muscular peak force when they were asked to kick as fast and as hard as possible in comparison to neutral and happiness conditions (Davis, et al., 2010; Woodman et al., 2009). Additionally, cross-sectional studies have shown that experiencing pleasant and high-approach emotions such as excitement and happiness (Uphill et al., 2014; Vast et al., 2010) were related to successful performance, whereas experiencing unpleasant and low-approach emotions such as anxiety and embarrassment were related to unsuccessful performance (Uphill et al., 2014; Vast, et al., 2010; Woodman & Hardy, 2003).

Although promising, it is not clear what drives these effects. Research on sports performance has shown that athletes benefit from high-approach negative emotion (anger) and high-approach positive emotions (happiness, excitement) compared to low-approach negative emotions (i.e., anxiety and sadness) (Rathschlag & Memmert, 2013, 2015). Based on those findings, the approach tendency may be the key element of successful performance. In this light, it is noteworthy that previous research on sports performance did not control for a range of approach tendencies that resulted from elicitated discrete emotions. This limits our inferences, because the anger that is generally associated with approach tendency (Harmon-Jones & Harmon-Jones, 2016) may also be associated with avoidance tendencies in the situations that are likely to co-induce anger and anxiety (Kaczmarek, Behnke, Enko et al., 2019; Zinner et al., 2008). Another limitation of these studies is that they did not compare multiple positive emotions; thus, it is not possible to determine if the beneficial effects of happiness were due to pleasant valence or approach tendency when compared to low-approach unpleasant emotions. Differentiation between high-approach and low-approach emotions is needed in order to understand the role of preperformance emotions in sports.

The Mediating Role of Challenge Responses

If high-approach emotions do, in fact, have beneficial effects on sports performance, what might explain these effects? One candidate mechanism is the challenge response, suggested by the biopsychosocial model of challenge and threat (Blascovich, 2008; Hase, O'Brien et al., 2019; Seery, 2011). In the context of performance, the challenge response is characterized by high approach-motivation, namely by energization of behavior directed toward the desirable goal (Blascovich, 2008; Elliot & Trash, 2002; Nicholls et al., 2014). Along with the high approach motivation, the challenge response is also characterized by physiological mobilization via increased blood flow throughout the body (i.e., increased cardiac output), which provides the efficiency of energy delivery required for successful performance (Blascovich, 2008; Seery, 2011). A final major component of the challenge response is the perception of the superiority of one's resources (e.g., skills, knowledge, and abilities) over the performance demands (e.g., opponents' skills, social expectations, and required effort). These motivational, physiological, and cognitive responses form a challenge response that is likely to facilitate the performance outcomes (Behnke & Kaczmarek, 2018; Behnke et al., 2020; Hase, O'Brien et al., 2019; Wormwood et al., 2019). In sports specifically, the challenge responses should facilitate performance via improved decision making and cognitive functioning, stronger task engagement, and increased anaerobic power (see Jones et al., 2009; Meijen et al., 2020, for the review).

Taken together, both the challenge state and high-approach emotions should lead to successful performance, due to shared characteristics, namely the energization of behavior directed toward the goal and increased cardiac efficiency (Jamieson et al., 2018; Kreibig, 2010; Siegel et al., 2018). Due to increased approach tendency and increased cardiac efficiency elicited by high-approach emotions, individuals might be more likely to evaluate their coping resources as surpassing demands. Thus, high-approach emotions might facilitate the challenge response. However, the exact mechanism or mechanisms by which high-approach emotions activate challenge might be different given how much remains to be learned about the complex, multifaceted nature of emotions and their influence on behavior.

Although emotions are usually conceptualized as consequences of motivational challenge/threat states (Jones et al., 2009), we propose that emotions may also precede and activate the challenge/threat responses (Trotman et al., 2018). In this way, challenge/threat responses would be elicited by initial emotional response, reflecting the spiral cycle of emotion generation and emotion regulation (Gross, 2015).

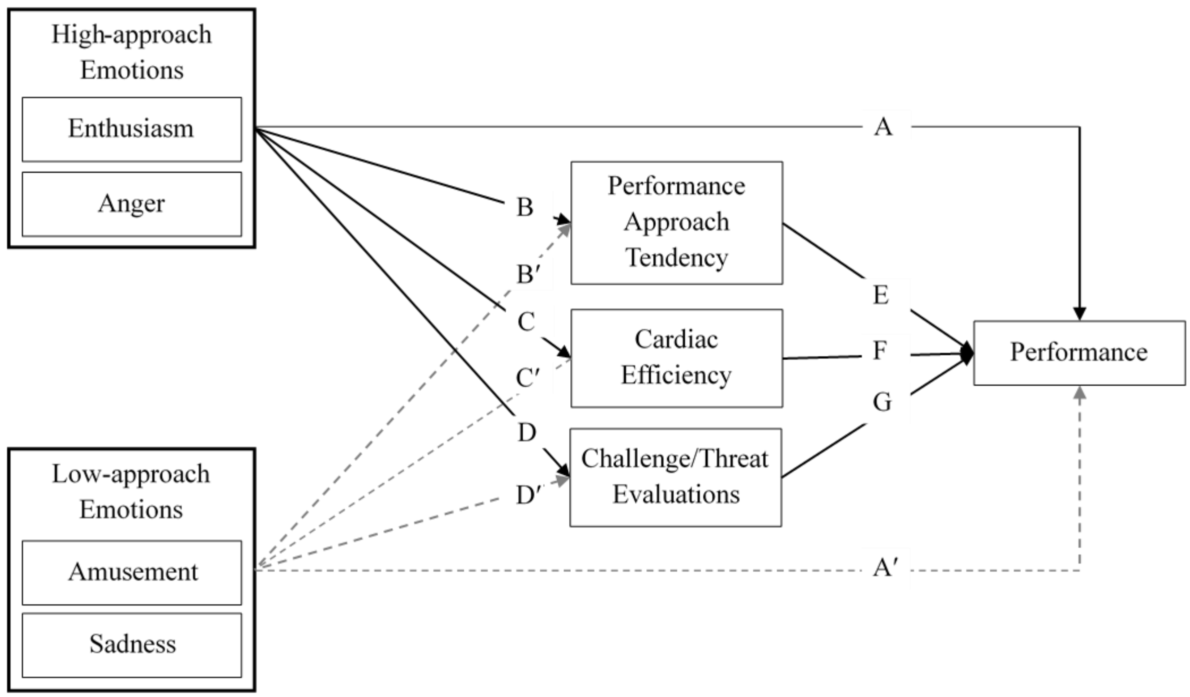
The Present Research

The aim of the present research was to examine the effects of preperformance emotions on sports competition, with particular focus on esports. In our study, participants played the video game *FIFA*, which is the leading video game in the sports simulation category with 45 million unique console and PC gamers worldwide (Electronic Arts Inc., 2019). In studying emotions, we focused on amusement, enthusiasm, sadness, and anger to fill in four cells in a valence (pleasant/unpleasant) and approach (low/high) 2 × 2 matrix. We manipulated targeted emotions with film clips. Each participant played five matches; each match preceded by induction of one discrete emotion and a neutral control clip.

Building upon the theoretical models relevant to the study of emotion and performance (Blascovich, 2008; Gable & Harmon-Jones, 2010; Seery, 2011), we formulated hypotheses regarding the direct effects of emotions on performance (Figure 1). We expected that motivational tendencies would drive the effects of emotions on performance rather than valence. In particular, we expected that high-approach emotions (anger and enthusiasm) would lead to better performance (Path A) compared to low-approach emotions (sadness and amusement) and neutral conditions (Path A′). Furthermore, we expected that high-approach emotions would elicit a stronger challenge response to the performance, as indexed by stronger approach motivational tendencies (Path B), increased cardiac efficiency (Path C), and stronger challenge-specific evaluations (Path D) compared to low-approach emotions and neutral conditions (Path B′, Path C′, Path D′). Finally, we expected that stronger challenge responses would lead to better performance, meaning that higher performance-related approach tendencies (Path E), higher cardiac efficiency (Path F), and stronger challenge evaluations (Path G) would be related to better performance.

Figure 1

Proposed Model for Role of Emotions in Esports Performance



Note. We grouped high-approach and low-approach emotions to simplify the figure. We expected the relations in regard to each emotion separately.

Based on predicted direct effects (single path or single regression coefficient), we also formulated three mediational hypotheses regarding indirect effects (the product of two paths or regression coefficients). We expected that high-approach emotions would lead to better performance via higher performance-related approach tendencies (Path BE), higher cardiac efficiency (Path CF), and stronger challenge evaluations (Path DG). The inclusion of mediators often increases power relative to testing total effects only (Kenny & Judd, 2013; O'Rourke & MacKinnon, 2015). Thus, testing mediations decreases the odds of type II error when less pronounced effects are studied. Past research has shown that performance in the sports and gaming field depends greatly on skills and previous gaming experience (Behnke et al., 2020), however, psychological influences, such as emotions, are secondary factors that are expected to produce significant yet less pronounced effects.

Method

Participants

Participants were 241 male gamers between the ages of 18 and 37 years (*M* = 23.63, *SD* = 3.63). A power analysis using G*Power 3.1 (Faul et al., 2009) indicated that detection of expected effect sizes of $f^2 = 0.10$ (Behnke & Kaczmarek, 2018), with the power of .90, would require a sample size of 217 participants, for a repeated measures design. We collected additional participants because we expected 10-15% of the sample to be lost due to recording problems in studies examining psychophysiological responses. We recruited gamers via a Facebook advertisement targeted at *FIFA 19*. Of the participants, 221 (92%) were recreational gamers, 19 (8%) were non-professional esports gamers (competing in local or online tournaments), and one (<1%) gamer did not report his status. Gamers had normal or corrected vision and no known history of cardiovascular or respiratory disease. Gamers' Body Mass Index (BMI) ranged from 16.85 and 35.55 kg/m^2 (*M* = 24.55, *SD* = 3.19). We asked participants to reschedule if they experienced illness or a major negative life event and to refrain from vigorous exercise, food, and caffeine for two hours before testing. We introduced the above restrictions to eliminate factors that might affect cardiovascular functions or usual gaming performance. Each participant provided written informed consent and received two vouchers for a cinema ticket for participation in the study. The institutional ethics committee approved the study.

Procedure

Participants were tested individually in a sound-attenuated and air-conditioned room. Upon arrival in the lab, participants provided informed consent, and the researcher applied sensors to obtain cardiovascular measurements. All instructions were presented, and responses were collected via a PC with a 23-inch screen. The experiment started with a five-minute baseline, during which we asked gamers to sit quietly. Next, participants completed five rounds consisting of: 1) two minutes of baseline; 2) watching a movie (emotion elicitation); 3) reporting discrete emotions they felt while watching the clip; 4) reporting challenge/threat evaluations; 5) playing the *FIFA 19* match. We operationalized the pre-film baseline as the indicator of a repeated resting state during the study.

To elicit emotion, we used stimuli from an emotion-eliciting video clip database, with prior evidence of reliability and validity (Kaczmarek, Behnke, Enko et al., 2019; Gross & Levenson, 1995; Schaefer et al., 2010). We used validated movie clips: 1) "A fish called Wanda" for amusement (Archie gets undressed, waiting for his girlfriend. Unexpectedly, the owners of the house get into the house and discover him naked); 2) "American History X" for anger (A neo-nazi smashes a Black man's head on the curb and killing him); 3) Summer Olympic Games for enthusiasm (montage of moments showing athletes successful performance and their joyful reactions); 4) `The Champ" for sadness (a boy cries at the death of his father); 5) "Blue" for neutral (A man clears out the drawers of his desk, or a woman walks in an alley, greets another woman, and continues walking). Each clip lasted two minutes. The session clips were presented in a counterbalanced order. The presentation of five clips resulted in 120 unique sequences that were randomly assigned to participants so that each sequence was assigned to at least two participants.

Our aim was to test how emotions elicited in gamers before the performance influence their subsequent actions. Thus, participants reported emotions felt after viewing the video clips (i.e., right before they started to play the game). Respecting the temporal order of variables in a model is essential for meeting assumptions of mediation testing (MacKinnon et al., 2007).

Moreover, preperformance self-reports predict the influence of challenge-type cardiac response on behavior better than retrospective self-reports (Trotman et al., 2018).

Participants played *FIFA 19 (*Electronic Arts Inc., USA). In this game, individuals compete with the standard soccer rules. The team that scores more goals than their opponents wins the match. To standardize conditions across participants, in each match, participants competed in a *Classic Match* mode playing their favorite team against Real Madrid controlled by computer avatars (bots) set at the professional difficulty level. Each match lasted eight minutes (two 4-minute halves). Upon completing the study, biosensors were removed, and the participants were debriefed.

Measures

Performance

We used the number of goals scored and lost during the match as the primary performance level indicator. Scoring more goals than the opponent is the final indicator of success in soccer. Thus we subtracted lost goals from the scored goals, with a higher number indicating better performance. We also used several secondary indicators of successful soccer performance, such as the number of shots on target, takeovers, fouls, accuracy of shots and passes, ball possession time, with a higher number of them (except fouls) indicating better performance. These indicators reveal the advantage of one team over another. We operationalized them as secondary indicators because soccer is a strategic game in which there are many possible ways to defeat the opponent.

Approach/Avoidance Tendencies

While gaming, participants continuously reported whether they felt the urge to approach or avoid a situation with a Response Meter (ADInstruments, New Zealand), on a scale from 1 (*extreme avoidance tendency*) to 10 (*extreme approach tendency*). Previous research indicated that individuals are able to report the intensity of their urge to approach or withdraw from a stimulus using rating scales (Cowen & Keltner, 2017; Kaczmarek, Behnke, Kosakowski et al., 2019; Marchewka et al., 2014). The ratings along the approach-avoidance dimension are relatively independent from ratings of valence and arousal. For instance, individuals report stronger approach tendency (but the same levels of valence and arousal) towards luxury goods or attractive individuals than towards happy elderly or unattractive individuals (Kaczmarek, Behnke, Kosakowski et al., 2019). Players were instructed and regularly prompted to adjust the scale whenever they experienced a substantial change in their approach-avoidance motivation. This was particularly feasible in moments when the gameplay was naturally halted due to a gaming event, and players were able to remove their hand from the gamepad (e.g., when the ball went out of the field, during player substitutions, after fouls and goals). Players were also free to pause the game and adjust the scale. Furthermore, we provided a validated approach-avoidance graphical scale modeled after the self-assessment manikin above the numeric scale. Graphical stickman was modeled based on previous research indicating that approach motivational tendency is related to leaning forward and reaching for an object whereas avoidance is related to moving away and reclining backward (Harmon-Jones et al., 2013; Harmon-Jones et al., 2011). The signal was sampled at a rate of 1000 Hz by Powerlab 16/35 (ADInstruments, New Zealand) and further processed using LabChart 8.19 software (ADInstruments, New Zealand). Electronic rating scales collect reliable and valid emotion ratings (Ruef & Levenson, 2007).

Challenge/Threat Evaluation

We conceptualized challenge and threat evaluations as the difference in perceived resources and demands (Tomaka et al., 1993; Seery, 2011). Situational demands were assessed by asking, "How demanding do you expect the upcoming game to be?" while gamers' resources were measured by asking, "How able are you to cope with the demands of the game?". Participants used a 7-point scale ranging from 1 (*not at all*) to 7 (*extremely*). This measurement method of demands and resources has been used in research on cognitive evaluations, cardiovascular responses, and sports performance (Hase, Hood et al., 2019; Moore et al., 2012, 2014). After subtracting demands for winning the match from gaming resources, the evaluation score ranged from -6 to +6 with positive scores reflecting high challenge and negative scores reflecting high threat.

Challenge/Threat Cardiovascular Response

Cardiovascular biosignals were recorded continuously and noninvasively with the Vrije Universiteit Ambulatory Monitoring System (VU-AMS, the Netherlands) following psychophysiological guidelines (Sherwood et al., 1990; van Lien et al., 2015). Impedance cardiography (ICG) and electrocardiography (ECG) recordings provided continuous measures of cardiac action and hemodynamic levels. We used pre-gelled AgCl electrodes (Kendall Abro, H98SG) placed in standard a Lead II configuration for ECG and a four-spot electrode array for ICG (Sherwood et al., 1990). After the VU-AMS Data, Analysis & Management Software (VU-DAMS 3.0) detected R-peaks in the ECG, we visually checked and adjusted all R-peak markers when necessary. We calculated pre-ejection period (PEP, time in milliseconds in the cardiac cycle from initiation of ventricular depolarization to opening of the aortic valve and ejection of blood) and cardiac output (CO, the amount of blood in liters pumped by the heart per minute).

Responses along the cardiovascular challenge/threat dimension were operationalized as responses in PEP and CO. Shorter PEP reflects sympathetic activation (Seery, 2011). Shorter PEP is characteristic of physiological readiness for a motivated performance and is considered a prerequisite for interpreting CO as a physiological indicator of psychological challenge and threat (Blascovich, 2008). This initial cardiovascular response leads to the challenge- or threat-specific reactions and depends on an individual's evaluations of resources vs. demands. Challenge evaluations lead to greater cardiac efficiency (i.e., increased CO), compared to threat evaluation that inhibits beneficial physiological mobilization (Seery, 2011). Traditionally, to operationalize challenge/threat responses, researchers also used total peripheral resistance (TPR, an index of net constriction vs. dilation in the arterial system) (Blascovich, 2008). However, due to the technical limitations - participants in our study used both hands during the game - we were not able to measure blood pressure and, in turn, calculate TPR.

Emotions

For the manipulation check, participants reported retrospectively using a single-item rating scales on how much of four targeted emotions (amusement, anger, enthusiasm, and sadness) they experienced while watching the movies. The scales range from 1 (*not at all*) to 7 (extremely).

Gaming Experience

FIFA gaming experience was operationalized as the number of hours spent playing the game during a regular week within the past month. Gamers reported that they played from 1 hour to 34 hours per week (*M* = 7.24, *SD* = 5.78).

Analytical Strategy

Physiological Data Reduction

Physiological measures were scored using 120-s ensemble averages (pre-film baseline and the five matches). To operationalize physiological changes, we used reactivity scores corrected for the resting state levels; thus, we subtracted the levels of the pre-film baseline from the matches. Using difference scores is a standard strategy for the study of autonomic responses to psychological factors (Gross & Levenson, 1995; Kreibig et al., 2013).

Manipulation Check

First, to test whether film clips elicit targeted emotions, we used repeated-measures analysis of variance (rmANOVA) with Greenhouse-Geisser correction and calculated effect sizes

(η^2). To examine differences between the conditions (e.g., whether self-reported amusement in response to the amusing film clips was higher than it was in response to the other film clips), we calculated pairwise comparisons reported as effect sizes (Cohen's *d*) with confidence intervals (95% CI). The difference is significant when 95% CI for the effect sizes did not include zero. We also used rmANOVA to demonstrate sympathetic activation while gaming. We compared PEP level during the match to PEP baseline levels before the film and match.

Primary Analysis

To examine the effects of emotions on esports performance, we used path analysis with maximum likelihood estimation with robust standard errors (MLR), using mPlus 7.2 (Muthén & Muthen, 2012). We regressed the primary indicator of performance level (the difference between scored and lost goals) and secondary indicators of performance level (the number of shots on target, takeovers, fouls, accuracy of shots and passes, ball possession) on the mediators (approach tendency, challenge/threat evaluations, cardiac efficiency) and experimental conditions (elicited emotions). We controlled for the gaming experience by introducing it as a covariate for performance level and the mediators. We dummy-coded the experimental conditions such that significant differences in the model accounted for differences relative to the neutral condition. To account for the non-independence of observations, we nested five rounds of responses within individuals (Muthén & Muthen, 2017; McNeish et al., 2017). We calculated RMSEA, the recommended fit index for the MLR. RMSEA estimator with values <.08, along with the CFI with values above .90 indicate acceptable fit (Bentler, 1990). After eliminating participants with missing data, we analyzed 928 rounds of responses (films and matches) nested within 208 gamers as each participant played five matches.

Results

Manipulation Check

As summarized in Table S1 and Table S2, watching film clips elicited the targeted emotions. Pairwise comparisons indicated that self-reported amusement was the highest in the amusing film condition, self-reported anger was the highest in the angry film condition, self-reported enthusiasm was the highest in the enthusiastic film condition, and self-reported sadness was the highest in the sad film condition (Table S3). Moreover, self-reported targeted emotions were highest in the corresponding film condition, (e.g., self-reported amusement was higher than self-reported enthusiasm in amusement film condition) (Table S4). Only in the angry condition, we observed that self-reported levels of anger and sadness did not differ $d = 0.04$, 95% CI [-0.14, 0.22]. All effect sizes with confidence intervals for pairwise comparisons for differences in self-reported emotions between and within conditions are presented in supplementary materials (Table S3-S4). Moreover, we found that gaming was characterized by increased sympathetic activation as indexed by shorter PEP ($M = 113.14$, $SD = 16.19$) when compared to pre-film baseline ($M = 115.22$, $SD = 15.44$), $d = 0.10$, 95% CI [0.01, 0.19], $F(1, 997) = 93.32$, $p < .001$.

Primary Analyses

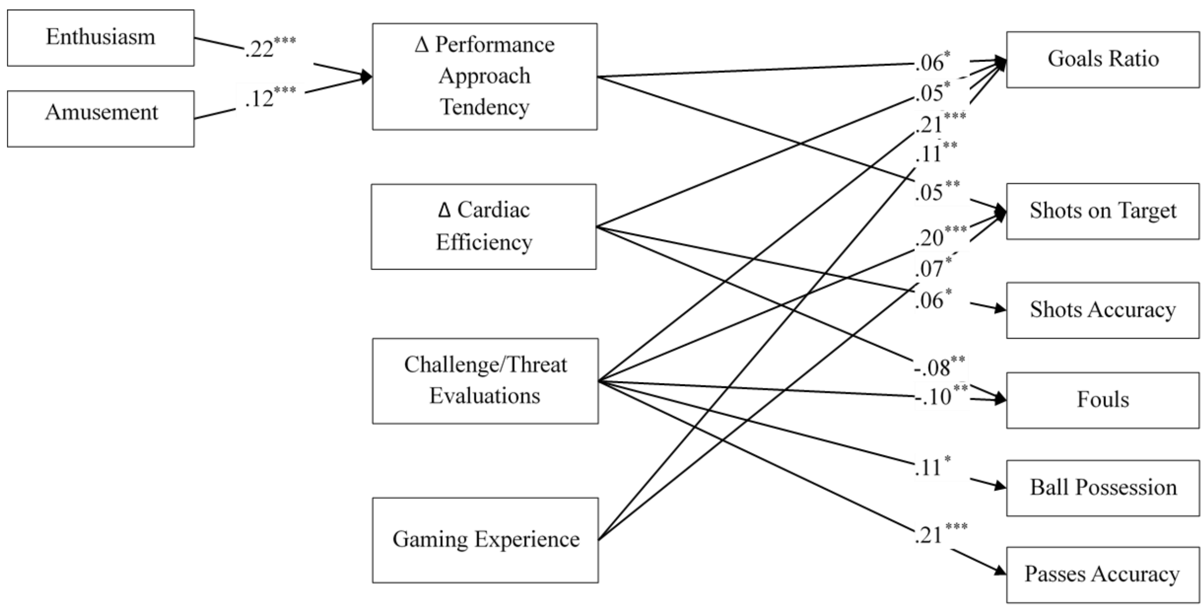
The final path model for the role of emotions in esports performance is presented in Figure 2. Descriptive statistics and correlations are presented in Table S5 and Table S6. This model fit the data well, $\chi^2(52) = 54.103$, $p = .39$, RMSEA = .01, 90% CI [.00, .02], CFI = .99. Non-significant paths had no effect on the model fit, $\Delta\chi^2(49) = 51.85$, $p = .36$, and were removed.

Did high-approach emotions lead to better performance compared to low-approach emotions and neutral conditions?

Emotions did not influence performance directly compared to neutral conditions. We found no differences between conditions across performance indicators.

Figure 2

Final Model for Role of Emotions in Esports Performance



Note. Δ = change scores relative to pre-flim baseline, Gaming Experience = number of hours played by week.

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Did high-approach emotions produce stronger challenge response*s *to the performance compared to low-approach emotions and neutral conditions?

We found that enthusiasm, $\beta = .22$, *95% CI* [.16, .28] and amusement, $\beta = .12$, 95% CI [.06, .18] (rather than enthusiasm and anger) influenced performance-related approach tendency compared to the neutral conditions (Figure 2). Effects of enthusiasm on approach tendency were higher than that of amusement $\Delta\beta = .10$, 95% CI [.03, .16], anger, $\Delta\beta = .23$, 95% CI [.14, .32], and sadness $\Delta\beta = .23$, 95% CI [.15, .30]. Moreover, effects of amusement on approach tendency were higher than anger $\Delta\beta = .13$, 95% CI [.05, .21], and sadness $\Delta\beta = .13$, 95% CI [.05, .20]. Unpleasant emotions did not influence approach tendency when compared to the neutral conditions. Moreover, emotions did not influence challenge/threat evaluations and cardiac efficiency compared to neutral conditions.

Did stronger challenge responses lead to better performance?

We found that motivational, cardiac, and cognitive indicators of the challenge response were related to better performance. First, higher approach tendency was related to positive goal difference, β = .06, 95% CI [.01, .11] (Figure 2) and number of shots on target, β = .05, 95% CI [.01, .10]. Second, gamers with higher cardiac output reactivity performed better as indicated by more positive goal difference, β = .052, 95% CI [.001, .103], higher accuracy of shots, β = .06, 95% CI [.01, .11], and lower number of fouls, β = -.08, 95% CI [-.14, -.02]. Third, gamers who displayed more positive challenge/threat evaluations achieved higher goal difference, β = .21, 95% CI [.13, .29], higher number of shots on target, β = .20, 95% CI [.13, .26], lower number of fouls, β = -.10, 95% CI [-17, -04], higher ball possession time, β = .11, 95% CI [.02, .20], and higher accuracy of passes, β = .21, 95% CI [.11, .30] (Figure 2).

Was the emotions' impact on performance mediated by challenge responses?

We found an indirect effect of enthusiasm and amusement on the game scores, namely mediation via a higher approach tendency (a full mediation). We found that gamers achieved better game results when their game was preceded by enthusiasm elicitation, indirect effect of β = .023, 95% CI [.003, .042], and amusement elicitation, indirect effect of β = .013, 95% CI [.001, .025], compared to the neutral condition because enthusiasm and amusement produced higher approach tendency (Figure 2). Moreover, the indirect effect of enthusiasm was stronger than the indirect effect of amusement, $\Delta\beta$ = .010, 95% CI [.001, .020]. Given no significant direct effect of emotions on performance, the effect of emotions on performance was fully mediated by approach tendency. We found no indirect effects of emotions on the performance that were operating via challenge/threat evaluations and cardiac output.

Did gaming experience influence the challenge response and performance?

We found that gaming experience did not influence the challenge response to the performance. However, gaming experience predicted better performance, as indicated by a more positive goal difference, β = .11, 95% CI [.03, .19], and gaming style, as indicated by a higher number of shots on target, β = .07, 95% CI [.01, .14] (Figure 2).

Discussion

We examined how emotions that differ in approach-avoidance tendencies and valence influenced performance outcomes in the esports context. We also examined whether cognitive (challenge/threat evaluation) and physiological (increased cardiac efficiency) processes would mediate any observed effects of emotions on performance. Contrary to expectations, we found no direct effects of emotions on the performance or challenge/threat response. However, our findings indicate that the influence of pleasant emotions on gaming-related outcomes was mediated by increased approach tendency. Moreover, across all conditions, gamers with higher challenge evaluations and increased cardiac efficiency performed better.

Implications for Motivation and Emotion

Our findings provide new evidence for the validity of the motivational dimensional model of affect. We found that elicited emotions characterized by pleasant valence differed in the intensity of approach tendency (Gable, & Harmon-Jones, 2010; Harmon-Jones et al., 2013; Kaczmarek, Behnke, Enko et al., 2019). We found that both pleasant emotions (amusement and enthusiasm) resulted in increased approach tendencies during the gameplay, compared to the neutral condition. However, enthusiasm produced stronger performance-related approach tendencies than amusement. This difference in approach tendency between enthusiasm and amusement translated into stronger positive behavioral effects for enthusiasm compared to amusement. This provides another functional argument that approach motivation is a meaningful element of the affective response (Harmon-Jones et al., 2013).

We limit our conclusion to emotions characterized by pleasant valence with no support for emotions characterized by unpleasant valence in this study. Gamers in the anger-provoking condition did not display the expected approach tendency (Gable & Harmon-Jones, 2010). This finding is likely to stem from the difference in methods of anger-elicitation that influence different forms of anger. We used a video clip (a racist attack) that elicited anger towards the attacker along with sadness resulting from empathic concern for the victim (Schaefer et al., 2010), whereas previous research on the motivational dimensional model of affect used self-reported trait anger (Harmon-Jones, 2003) or provoked anger by insulting participants (Harmon-Jones & Peterson, 2009). Therefore, our findings generalize to situations where anger commingles with sadness and might be different for anger less infused with other unpleasant emotions. Our study is in line with some previous studies which indicated that anger occurs in low-approach situations (Kaczmarek, Behnke, Enko et al., 2019; Zinner et al., 2008) and should not always be treated as high-approach emotion (Carver & Harmon-Jones, 2009).

Implications for Motivation, Emotion, and Sports Performance

Our results integrate previous studies which indicated that pleasant emotions produce behavioral approach tendencies (Carver & White, 1994; Fredrickson, 2001) as well as studies showing that approach motivation promotes better performance (Friedman & Förster, 2005; Gable & Harmon-Jones, 2008; Roskes et al., 2011, 2013; Stoeber et al., 2009). Although emotions did not influence successful gameplay directly, we found that the effects of emotions on outcomes were fully mediated by approach-avoidance motivational tendencies. We demonstrated that individuals are more likely to benefit from pleasant emotions relative to neutral affect preceding the performance (Rathschlag & Memmert, 2013, 2015; Totterdell, 2000). Moreover, our findings indicated that elicited unpleasant emotions have no detrimental impact on performance (Nicholls et al., 2012; Turner et al., 2012; Turner et al., 2013). We found that emotions influenced actions as long as they served to increase the approach motivational tendency, which is essential in mobilizing resources for successful performance (Park & Mendes, 2014).

The occurrence of mediation of effects that were deemed to be insignificant in the first place might be puzzling. Such a pattern is likely to emerge in mediation testing due to different levels of statistical power when testing direct and indirect effects (Kenny & Judd, 2013; O'Rourke & MacKinnon, 2015). Indirect effects, which are products of two or more coefficients, usually have more statistical power than single coefficients that represent direct effects. This might be the case for the present study, where the effects of emotions that we found were relatively small with standardized betas ranging from .12 to .22. Our findings indicate the advantage of the mediational analytical plan but also indicate that even greater statistical power would be required to ascertain that the effects of emotions on gaming behavior are likely to replicate in studies that use different or no mediators.

This study has practical implications. We presented the effects of watching enthusiasm-inducing and, to a lesser extent, amusing material to increase the performance-related approach motivational tendency, and, in turn, improve gaming performance. During gaming events, it might be useful for gamers to watch highlight videos, such as video montages of famous players performing well in past events. Moreover, gamers might create personal clips presenting their best plays to provide optimal preparation for performance. Finding new ways to facilitate performance is essential in sports and esports where players often present similar levels of professional competence, and winning or losing depends on peripheral factors such as emotions (Gould, Dieffenbach et al., 2002; Gould, Greenleaf, et al., 2002; Pedraza-Ramirez et al., 2020). This study also is important because gaming and esports have been increasingly useful and popular during the COVID-19 pandemic. Video games offer a means to maintain high-quality entertainment during increased social isolation.

Linking Emotion and Challenge-Threat

Across all conditions, we found that the challenge-response for the upcoming performance predicted beneficial behavioral outcomes. This finding supports previous theories and studies that indicated how challenge evaluation and increased cardiac efficiency improves coping in stressful situations (Behnke et al., 2020; Blascovich, 2008; Hase, Hood et al., 2019; Moore et al., 2014). The present findings contribute to this literature by extending the generalizability of challenge/threat evaluations to esports. The replication aspect of this study is essential because several studies indicated that the effects presented in psychological literature are often not reproducible (Open Science Collaboration, 2015). This study also contributes to the diversity of empirical evidence for the biopsychosocial model of challenge and threat (Behnke & Kaczmarek, 2018). We added to the existing literature that accounted for types of performance that were central to participants' area of interest including surgery (Moore et al., 2014), aviation (Vine et al., 2015), university exams (Jamieson et al., 2010), softball (Blascovich et al., 2004), cricket (Turner et al., 2013), and soccer (Dixon et al., 2020).

Despite recognizing the role of challenge responses in the esport context, we observed that the challenge response was not influenced by the elicitation of emotions. These findings run contrary to some previous theoretical considerations (Jamieson et al., 2018; Jones et al., 2009) and evidence from empirical studies that indicated a link between challenge and pleasant emotions and threat and unpleasant emotions (Nicholls et al., 2012; 2014; Trotman et al., 2018; Williams et al., 2010), and general conceptual similarities between challenge response and high-approach emotions (Blascovich, 2008). However, our findings are consistent with other works that emphasize the ambiguity of the association between emotions, the challenge/threat states, and performance (Meijen et al., 2013; 2014; Turner et al., 2012, 2013; see Meijen et al., 2020, for the review). This ambiguity may result from the fact that the same emotion can be functional or dysfunctional, depending on individuals' evaluation and beliefs (Tamir & Bigman, 2018).

Our investigation is important because it adds to testing the variety of methods used to upregulate the challenge-response. Previous studies indicated that challenge evaluation could be upregulated by encouraging task instructions (Moore et al., 2012), performance-related feedback (Behnke et al., 2020), self-talk (Hase, Hood et al., 2019), reappraising arousal (Sammy et al., 2017), or imagery (Williams et al., 2010). We found that our method of preperformance emotion elicitation influences behavior via a different pathway, namely, increased approach tendency rather than increased challenge evaluations. Future studies might examine further experimental methods (e.g., behavioral) that could result in an upregulated challenge response.

Limitations and Future Directions

The study has several limitations that bear noting. First, we observed that the previously validated short videos that we used elicited multiple emotions rather than the targeted emotion exclusively. It limits the interpretation of effects produced by a single emotion. In the case of amusing, enthusiastic, and sad video clips, we found expected self-reported emotions. We found the video clip that produced anger to be more problematic. Anger is triggered by external factors that pose a threat (physical or psychological) to an object or an individual that is personally meaningful (Ekman & Cordaro, 2011). Anger triggers the action of removing the obstacle or stopping the harm involving the wish to hurt the target (Ekman & Cordaro, 2011). In the video that we used in our study, the oppressor killed his victim. Thus, the clip elicited anger and sadness. The levels of sadness that our participants reported were higher than those of sadness reported in the validation study (Schaefer et al., 2010). Future research might pursue increasingly accurate methods to induce anger that is not accompanied by other negative emotions

(Kaczmarek, Behnke, Enko et al., 2019; Zinner et al., 2008). Furthermore, the enthusiastic clip presenting athletes was the video that most closely reflected the participants' experience. The similarity between the stimulus and participants' current situation might be the reason why this clip was the most engaging and motivating for participants. Future studies might use a variety of enthusiastic clips unrelated to sports activities.

Second, we focused on a single esports context. Although esports mimic the psychological demands of traditional sports performance, esports is an activity that takes place in a seated position and is relatively less energy-intensive than its traditional equivalent. This may limit the generalization of our results to precision sports like snooker or motorized sports. Moreover, soccer videogame requires creative plays and fast decision-making, similar to traditional team sports, including soccer or basketball. Emotions could have different implications in self-paced sports that require optimal execution of a well-trained task with the maximum effort, namely gymnastics, swimming, running, or weightlifting. Future studies might refine our understanding of the links between specific emotions and performance-related outcomes.

Third, we focused on four discrete emotions, namely amusement, anger, enthusiasm, and sadness. Thus, these emotions fill in four cells in valence (pleasant/ unpleasant) and approach (low/high) 2 × 2 matrix. However, an exhaustive list characterizing emotional experience might also account for other dimensions (e.g., arousal, attention, certainty, dominance)(Cowen & Keltner, 2017). Future studies may examine the influence of other emotions common for sports performance (e.g., pride, schadenfreude, contentment, or preperformance anxiety), along with studying differences across other dimensions such as arousal or dominance. This is important to address alternative interpretations, such as arousal effects on performance (Arent & Landers, 2003).

Fourth, we limited our focus to a small number of specific measures related to physiological challenge/threat response and approach tendencies. For instance, we did not include TPR – the second index of challenge/threat physiological response. Participants in our study used both hands during the game. Thus, we were not able to measure blood pressure and, in turn, TPR. However, a recent meta-analysis showed that CO and TPR are both equally predictive for pleasant performance outcomes (Behnke & Kaczmarek, 2018). Moreover, CO and TPR showed more predictive effects when used independently in comparison to the use of the combination of CO and TPR as the challenge/threat index (Behnke & Kaczmarek, 2018). In future studies, it may be helpful to obtain a broader range of approach-related measures.

Fifth, we measured challenge/threat cardiac responses during the performance (Behnke et al., 2020; Frings et al., 2015; Mendes et al., 2002) rather than before the performance (Moore et al., 2012; Turner et al., 2012). Both approaches have their specific advantages and limitations that should be considered in assessing the fit of the approach with the current research aims. Some authors advocate for the measurement of cardiac patterns during the performance because this is the actual period where increased cardiac efficiency is expected to influence performance outcomes as it was the case in our study (Arthur et al., 2019). Above all, the focus of this experiment was on the effects of elicited emotions on performance. Thus, we aimed to initiate the performance immediately after the emotions elicitation rather than separating the emotion elicitation from the performance with a break dedicated to the measurement of cardiovascular levels. Regardless of the benefits of the measurement of cardiac patterns during the performance, it is possible that the results might have been different if we had measured the link between preperformance challenge/threat indexes and the gaming outcomes. This is because levels during gameplay might have been influenced by the ongoing performance along with its sub-effects (scoring a goal early in the game) that contribute to the final performance outcome (the final difference between scored and lost goals). Moreover, as noted above, esports have the advantage that the physical activity is minimal, relative to athletics or team sports that require gross body movements. Yet, the cardiac effects might have been influenced by physical activity. For instance, individuals who were losing and experiencing negative emotions might have produce more tonic muscular tensions (Huis in't Veld et al., 2014). Future studies might compare whether preperformance cardiac levels are equally predictive of performance outcomes as performance cardiac levels. These studies might focus on how gaming sub-effects influence challenge/threat dynamic and whether gaming cardiac patterns are significantly influenced or mediated by modulation of muscular tension.

Sixth, with the path analysis, we expected linear relations between challenge/threat physiological response and performance. Recent studies suggested the occurrence of the third type of response, namely blunted response (no reactivity; Dixon et al., 2020; Wormwood et al., 2019) that might lead to even more detrimental effects for performance, compared to threat response (Hase et al., 2020). Future studies on emotions and gaming performance might pursue this line of studies.

Finally, our participants were all young male gamers. It reflects the situation among sport-type gamers, where the vast majority, up to 98%, are male (Yee, 2016). Therefore, our results apply to male gamers, whereas future studies might focus on whether the results generalize to older and female gamers.

In summary, this study helps to clarify the link between emotions and sports performance. Notable strengths of this study include the use of an experimental approach with a large sample of highly motivated individuals in an esports performance context. This study also used a multi-method approach in order to assess affective, cognitive, and physiological responses in this gaming context. Using this multi-method approach, we found that emotions influence actions as long as they serve to increase the approach tendency. These results inform our understanding of how approach tendency and valence contribute to performance.

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