

Title	仮想力場環境における到達把持運動の適応的変化の検討
Sub Title	Adaptive changes of reach-to-grasp movements to a virtual force field
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Abstract	<p>ロボットデバイスを用いた仮想力場環境を構築し, その影響下における到達把持運動の適応的変化を検討した。実験では, 参加者は粘性力場における水平到達把持運動を繰り返し実施した。到達把持運動は, 30試行の力場なし ( pre NF ), 100試行の力場あり ( FF ), 30試行の力場なし ( post NF ) ブロックの順で実施された。参加者の手首の下に水平2リンクマニピュラタムの先端が取り付けられ, 運動方向に対して14N m/sの抵抗が与えられた。到達把持運動の際の親指と人差し指の開き幅 ( Aperture ) を計算し, いくつかの運動学的指標を求めた。</p> <p>実験の結果, 運動時間はFFブロック初期で顕著に増加し ( 約300 ms ), 試行が進むにつれてわずかに減少した。ブロック初期・後期の平均値を用いた解析からは, MGA ( 指の最大開き幅 ), MGA timing ( MGAが出現する%タイミング ), plateau duration ( MGAの90%以上が持続する%期間 ) に関してFF初期とPre NFの間に有意な差は見られなかった。ただし, FFブロック内の回帰分析からは, 試行が進むにつれてそれぞれの指標が変化する傾向が確認された。主成分分析によって第1主成分 ( - MGA, + MGA timing, + Plateau start, - Plateau duration ) と第2主成分 ( + MGA ) の時系列変化を検討したところ, 主に第1主成分が時系列的に変化していることが明らかとなった。これらの結果は総じて, 到達把持運動における到達成分と把持成分が, 外乱による運動時間の延長や努力の増大の影響を受けずに, 協調的に制御されていることを示唆する。</p> <p>The present study used a viscosity force field, where the resistance force was applied to the participant's wrist against the movement direction (not rotating force), to investigate the time course of adaptive kinematic changes in reach-to-grasp movement. Ten right-handed young adults participated in the experiment. They performed reach-to-grasp movements for a cylindrical target with a 2 cm diameter and 2 cm height located on 26 cm away from a start point. The experiment consisted of 30 trials of pre and post movements with a null force field (NF) and 100 trials with a viscosity force field (FF) (14Nm/s). The participants were instructed to perform the movements in their natural speed. Reflective markers were put on the tips of thumb and index finger and the wrist, and their 3D positions were sampled at 60 Hz by an optical motion capture system (Smartrack, ART, inc.). Grasping aperture was calculated using the thumb and index finger position. The average performance of the last 5 trials of the pre-NF block was used as a baseline and compared with the average of the first 5 trial of the FF block. Regression coefficients were calculated to evaluate the adaptive change in the FF block.</p> <p>The results showed that (1) movement time evidently increased (about 300 ms) at the early FF phase from the baseline. It slightly decreased as the trials proceed while was still longer than the baseline; (2) MGA, MGA timing (% of the movement time), and plateau duration (% of the movement time), which is the relative length of the period where the aperture is larger than 90 % of MGA, did not change at the early FF phase. However, they gradually decreased, postponed, or lengthened as the trials proceeded, respectively. These findings indicate that the controls of reach and grasp movements were well coordinated regardless of the large increase of reach effort and movement time due to the applied external force against the reach. In addition, the results suggest that adaptive changes occurred in the FF block, although it is still unclear whether the changes were attributed to the applied force.</p>
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仮想力場環境における到達把持運動の適応的変化の検討						
研究課題 (英訳)						
Adaptive changes of reach-to-grasp movements to a virtual force field						
1. 研究成果実績の概要						
<p>ロボットデバイスを用いた仮想力場環境を構築し、その影響下における到達把持運動の適応的変化を検討した。実験では、参加者は粘性力場における水平到達把持運動を繰り返し実施した。到達把持運動は、30 試行の力場なし (pre NF)、100 試行の力場あり (FF)、30 試行の力場なし (post NF) ブロックの順で実施された。参加者の手首の下に水平 2 リンクマニピュラタムの先端が取り付けられ、運動方向に対して 14Nm/s の抵抗が与えられた。到達把持運動の際の親指と人差し指の開き幅 (Aperture) を計算し、いくつかの運動学的指標を求めた。</p> <p>実験の結果、運動時間は FF ブロック初期で顕著に増加し (約 300 ms)、試行が進むにつれてわずかに減少した。ブロック初期・後期の平均値を用いた解析からは、MGA (指の最大開き幅)、MGA timing (MGA が出現する%タイミング)、plateau duration (MGA の 90%以上が持続する%期間) に関して FF 初期と Pre NF の間に有意な差は見られなかった。ただし、FF ブロック内の回帰分析からは、試行が進むにつれてそれぞれの指標が変化する傾向が確認された。主成分分析によって第 1 主成分 (-MGA, + MGA timing, + Plateau start, -Plateau duration) と第 2 主成分 (+ MGA) の時系列変化を検討したところ、主に第 1 主成分が時系列的に変化していることが明らかとなった。これらの結果は総じて、到達把持運動における到達成分と把持成分が、外乱による運動時間の延長や努力の増大の影響を受けずに、協調的に制御されていることを示唆する。</p>						
2. 研究成果実績の概要 (英訳)						
<p>The present study used a viscosity force field, where the resistance force was applied to the participant's wrist against the movement direction (not rotating force), to investigate the time course of adaptive kinematic changes in reach-to-grasp movement. Ten right-handed young adults participated in the experiment. They performed reach-to-grasp movements for a cylindrical target with a 2 cm diameter and 2 cm height located on 26 cm away from a start point. The experiment consisted of 30 trials of pre and post movements with a null force field (NF) and 100 trials with a viscosity force field (FF) (14Nm/s). The participants were instructed to perform the movements in their natural speed. Reflective markers were put on the tips of thumb and index finger and the wrist, and their 3D positions were sampled at 60 Hz by an optical motion capture system (Smarttrack, ART, inc.). Grasping aperture was calculated using the thumb and index finger position. The average performance of the last 5 trials of the pre-NF block was used as a baseline and compared with the average of the first 5 trial of the FF block. Regression coefficients were calculated to evaluate the adaptive change in the FF block.</p> <p>The results showed that (1) movement time evidently increased (about 300 ms) at the early FF phase from the baseline. It slightly decreased as the trials proceed while was still longer than the baseline; (2) MGA, MGA timing (% of the movement time), and plateau duration (% of the movement time), which is the relative length of the period where the aperture is larger than 90 % of MGA, did not change at the early FF phase. However, they gradually decreased, postponed, or lengthened as the trials proceeded, respectively. These findings indicate that the controls of reach and grasp movements were well coordinated regardless of the large increase of reach effort and movement time due to the applied external force against the reach. In addition, the results suggest that adaptive changes occurred in the FF block, although it is still unclear whether the changes were attributed to the applied force.</p>						
3. 本研究課題に関する発表						
発表者氏名 (著者・講演者)	発表課題名 (著書名・演題)	発表学術誌名 (著書発行所・講演学会)	学術誌発行年月 (著書発行年月・講演年月)			
Yoshihiro Itaguchi	Reach-to-grasp movement in a viscosity force field.	The 30th Annual Meeting of Society for the Neural Control of Movement	April, 2021			