**Coordination generates commitment to a partner by signaling her willingness to adapt**

Coordination is ubiquitous throughout our day-to-day lives. During the daytime we coordinate actions and decisions together with our colleagues at work, and in the evening we coordinate in order to cook dinner or make social plans with family and friends. In addition to helping us to achieve instrumental goals more efficiently than we otherwise could, the process of coordination is often experienced as being rewarding in itself: from singing together with the congregation at church, to dancing with friends or strangers at a nightclub, many cultural practices attest that people enjoy and value coordinating with others even in the absence of any instrumental goal. Moreover, there is a wealth of research showing that coordination generates important indirect benefits by boosting prosocial attitudes and motivations: strengthening social bonds (Reddish, 2012), enhancing trust and rapport (Launay, Dean & Bailes, 2013; Hove & Riesen, 2009), and increasing cooperation and helping (Wiltermuth & Heath, 2009; Reddish, Fischer & Bulbulia, 2013; Rusch & Luetge, 2015; Valdesolo & DeSteno, 2011).

Building on this research, interpersonal coordination has also been shown to generate a sense of commitment, leading people to persist longer on a boring or effortful task to benefit their co-actor (Michael, Sebanz & Knoblich, 2016a). Commitment serves as a glue holding human social life together insofar as it boosts people’s willingness to invest time and effort to benefit a co-actor or a group to which they belong. (Michael, Sebanz & Knoblich, 2016b). Commitment is therefore crucial not only in sustaining small-scale social interactions unfolding over brief timescales, such as dancing or painting a house together, but also in providing the stability and predictability required for large-scale collective actions, such as combating climate change or pandemics, which involve sustained effort and personal sacrifice over longer timescales. The current study aimed firstly to build on earlier findings suggesting that coordination fosters commitment; and secondly, to identify which features of coordinated social interactions lead people to develop a sense of commitment towards their co-actor.

Broadly speaking, most theories concerning the mechanism by which coordination fosters prosocial attitudes and motivations are based on the core idea that coordination provides a *cue to similarity* between actors. This is because agents engaging in joint actions or in joint decision-making often have similar goals and exhibit similar movements. More specifically, it has been suggested that, by cueing similarity with another actor, coordination leads us to project our own positive traits onto the co-actor (Miles, Nind & Macrae, 2009), that it increases self-other overlap (Cirelli, 2018), or that it increase awareness of our roles as interdependent units of a group (Cross, Turgeon & Atherton, 2019).

However, there is another feature of coordinated interactions which may also give rise to prosocial attitudes and motivations. Specifically, successful coordination requires actors and decision-makers to *adapt* to each other. By adapting their movements and their decisions, people facilitate alignment with their partners, and can even adapt in ways that make their actions and decisions easier for their partners to align with (Keller, Novembre & Hove, 2014; Pezzulo, Donnarumma & Dindo, 2013; Bacharach, 2006; Bardsley et al., 2010; Schelling, 1960). In other words, *adaptation reflects an investment of effort*, insofar as it requires an agent to incur an individual cost in order to reduce the (e.g. planning) costs for their partner and/or to increase the chances of jointly succeeding (Török, Pomiechowska, Csibra & Sebanz, 2019; Green et al., 2019).

Indeed, when coordinating with others in dance or in music, we appreciate partners who are sensitive to our mood and style, who can flexibly shift between leading and following, and who can perform in ways that complement our own contributions. When viewed from the outside, the results can appear effortless, but expert performers can attest that a substantial investment of effort goes into ensuring the alignment of actions in space and time that is required to achieve a great performance. In a similar vein, politicians are most successful in reaching a broad range of voters and securing public support when they make the effort to see things from others’ perspectives and to identify areas of common ground to build upon. Indeed, these kinds of effort investments not only facilitate the coordination of actions and the creation of consensus in group decision-making, but also contribute to the cultivation of a group identity and a sense of commitment to the group, which can help to motivate people to endure hardships and to make sacrifices for the greater good.

For this reason, a co-actor’s adaptation may provide an important signal that she is a reliable interaction partner, and that it is therefore worth cultivating a collaborative relationship with her If this is correct, then we should expect coordination with an adaptive co-actor to boost people’s sense of commitment to that partner, increasing their willingness to reciprocate by investing effort or otherwise making sacrifices to benefit that partner. This would be consistent with recent research demonstrating that when an agent invests effort in a joint action, this increases her partner’s a sense of commitment towards the joint action and towards that actor, leading her to persist longer on a boring and effortful task (Szekely & Michael, 2018; Chennells & Michael, 2018).

The two experiments reported here were designed to disentangle *adaptation* and *similarity* as distinct factors driving the effects of coordination upon commitment. Thus, we aimed to test the following two distinct (yet compatible) hypotheses. The first hypothesis posits that a partner’s attempt to adapt her actions or decisions signals that she is willing to invest effort in order to reduce your costs and to maximise the chances of success, indicating that she is a useful and reliable partner, thus leading you to feel more committed towards her. The second hypothesis posits that coordinating with a partner provides a cue to similarity, leading her to feel more committed towards you.

In Experiment 1, we tested these hypotheses by having participants coordinate drum taps with an adaptive and an unadaptive partner before measuring how committed they were to each of these partners. We manipulated the *adaptivity of the partner* by manipulating whether the partner could hear their own taps only (and was therefore not able to adapt to the participant) or could hear both their own and the participants taps (and was therefore able to adapt to the participant).

However, adapting their movements to one another would also yield similarity, specifically meaning that compared to the unadaptive partner’s taps, the timing of the adaptive partner’s taps would be more similar to the timing of the participant’s taps. Because of this, we teased similarity and adaptation apart by manipulating whether or not the participants believed that their partner could hear them, therefore manipulating their belief about the partner’s *ability to adapt* (see figure 1 for a graphical representation of the design). We assumed that if participants believed that their partner could not hear them, then they would attribute the lack of adaptivity simply to the partner’s inability to adapt under the circumstances. However, if participants believed that their partner could hear them, then they would attribute the lack of adaptivity to an unwillingness or lack of motivation to adapt.

We then measured commitment by measuring how long participants would engage in a boring and effortful task to earn points for each of their partners. Specifically, participants would tap the spacebar in order to charge onscreen batteries for the adaptive and unadaptive partner (eight batteries for each partner). They were told that each partner’s payoff for the experiment depended on how much they (the participant) charged each of their batteries.

If similarity yields a sense of commitment, we should expect that participants would charge the batteries more (thereby allocating more points) for the adaptive partner than for the unadaptive partner, regardless of their belief about whether or not they could adapt. However, if adaptation generates a sense of commitment insofar as it constitutes an investment of effort, participants should charge the batteries more for the adaptive partner than the unadaptive partner, but only in the bidirectional belief condition, when they believed that their partner had the ability to adapt.

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| --- | --- | --- | --- |
|  | unadaptive | adaptive |  |
| Pp believes partner can hear her | low coordination  lower perceived effort | high coordination  higher perceived effort |  |
| Pp believes partner cannot hear her | low coordination  n/a perceived effort | high coordination  n/a perceived effort |  |
|  |  |  |  |

**Results & Discussion**

**Experiment 1**

In order to investigate the extent to which participants invested effort to charge the adaptive and unadaptive partner’s batteries in the two conditions, we carried out a 2x2 mixed ANOVA with partner (adaptive, unadaptive) as a within subjects factor, and belief (bidirectional, unidirectional) as a between subjects factor. The ANOVA revealed a significant main effect of partner, F(1,50) = 28.69, p < .001, $ = .327, but no main effect of belief, F(1,50) = .016, p = .9, $ .001. Importantly, we found a significant interaction between partner and belief, F(1,50) = 9.16, p = .004, $ = .104 (see figure 1), demonstrating that participants were relatively more committed to the adaptive partner than the undaptive partner when they attributed lack of adaptivity down to unwillingness to adapt, rather than inability to adapt.

However, post hoc t-tests showed that participants charged the adaptive partner’s battery more than the unadaptive partner’s battery in both the bidirectional belief condition, t(25) = 4.63, p < .001, d = .91, and the unidirectional belief condition, t(25) = 2.57, p = .011, d = .51, demonstrating that participants were overall more committed to the adaptive partner, regardless of their belief about whether or not the unadaptive partner was unwilling or unable to adapt.

These results show that although similarity regardless of the belief about willingness to adapt may play a role in the emergence of commitment, whether or not our partner is willing to invest effort in order to ensure the success of the interaction, in this case adapting movement timing, is central to the development of a sense of commitment towards our partner.

In order to control for fatigue throughout the experiment, we carried out a linear mixed effects model, with partner and belief as fixed effects and trial number as a random effect. This analysis revealed a significant effect of partner, z = -3.572, p < .001, but no effect of belief, z = -.494, p = .622. However there was an interaction between partner and belief, z = 2.339, p = .019, even when trial number was controlled for, demonstrating that our effects cannot be explained simply by differences in fatigue or motivation.

*Controlling for similarity*

In order to further tease apart adaptivity and similarity, we probed the extent to which the effect depends on how similar the two actors’ timing was, using asynchrony in the drumming task as an index of similarity (lower asynchrony means more similarity regarding movement timing). Firstly, a 2x2 ANOVA on the asynchrony data yielded a significant main effect of partner F(1,50) = 25.69, p<.001, $ = .338 but no main effect of belief, F(1,50) = .02, p = .89, $ = 0, or no significant interaction between partner and belief, F(1,50) = .23, p = .63, $ = .003 (see figure 2), demonstrating that patterns of asynchrony were the same in both conditions, meaning that the differences in synchrony cannot explain the differences in commitment we observed between participants in the two groups. We also carried out a linear mixed effects model (LMM), with partner and belief as fixed effects adding asynchrony as a random effect, allowing us to control for any variability associated with similarity of movement timing, allowing us to isolate the effect of adaptivity. This analysis revealed a significant effect of partner, z=-2.168, p= .03, but no effect of belief, z =,-1.319, p = .187. Importantly, even with overall similarity controlled for, the interaction between partner and belief was still significant, z = 2.202, p = .028. Overall, this demonstrates that our findings cannot be explained simply by different patterns of movement timing similarity in the two groups, providing additional evidence that adaptivity fosters commitment independently of similarity. This finding also allows us to rule out coordination success as a potential factor driving the relationship between coordination and commitment, as this would predict that the participants would be more committed to the adaptive partner due to more successful coordination with this partner, regardless of any belief about willingness to adapt.

**Experiment 2**

Our first experiment demonstrated that coordination fosters commitment to a co-actor insofar as it provides evidence of a co-actor’s willingness to invest effort in a joint action by adapting the timing of their movements, and thereby signals that the co-actor is a reliable partner. Crucially, the effect of coordination upon commitment which we observed cannot be explained by the hypothesis that coordination provides a cue to similarity with the co-actor. In Experiment 2 we aimed to generalize this finding to other contexts beyond that of action coordination, which was the focus in Experiment 1. In particular, we aimed in Experiment 2 to investigate whether decision-making coordination also leads people to attribute to their partner a willingness to adapt, and thereby boosts commitment to that partner. Decision-making coordination, like action coordination, is a pervasive and crucial feature of every life -- from choosing to drive on the right (or left) side of the road, deciding what film to watch with one’s partner, and political parties forming strategic coalitions to enact their legislative agendas (Schelling, 1960; Cooper et al., 1990; van Huykck et al., 1990). Moreover, it has also been shown that decision-making coordination, like action coordination, has positive effects upon agents’ prosocial motivations (Guala & Mittone, 2010; Rusch & Luetge, 2016). Thus, we designed Experiment 2 to investigate how similarity and adaptation contribute to the development of commitment towards a co-actor with whom we coordinate decisions. Participants first coordinated decisions with either an adaptive or an unadaptive actor, before we measured how committed the participant was to each of these partners.

For the coordination task, the participant and partner both had a workspace containing three gabor patches, two of which had a matching orientation, with their goal being to repeatedly coordinate their choices by choosing one of the gabor patches with the same orientation. Importantly the workspaces were always set up in a way in which one of the partner’s options would be easy for the participant to coordinate with (because this choice would be more distinguishable for the participant), and one of the partner’s options would be difficult for the participant to coordinate with (because this choice would be less distinguishable for the participant). We programmed the adaptive partner to have a preference for the gabor patch that was easily distinguishable, making it seem like it was making a decision based on consideration of the participant’s perspective, reflecting an investment of cognitive effort in order to make the task as easy as possible for the participant. We programmed the unadaptive partner to have a preference for the gabor patch that was difficult to distinguish, making it seem like it was making decisions without any investment of effort in considering the participant’s perspective.

As in Experiment 1, the adaptive partner would also be more similar to the participant (the adaptive partner would prefer the gabor patch that the participant also prefers). In order to tease similarity and adaptation apart, we manipulated the participant’s belief about whether or not the partner could see both (or only their own) workspaces, thus manipulating the participant’s belief about the partner’s ability to adapt. We assumed that if participants believed that their partner could only see their own workspace, then they would attribute the lack of adaptivity simply to the partner’s inability to adapt under the circumstances. However, if participants believed that their partner could see both workspaces, then they would attribute the lack of adaptivity to an unwillingness to invest cognitive effort to adapt their choices for the sake of the participant. In order to measure commitment, we employed the same battery charging task in Experiment 1, with the participant charging eight batteries for the adaptive partner, and eight batteries for the unadaptive partner.

One possibility is that like with action coordination, decision-making coordination fosters commitment because a co-actor’s adaptation of their decisions reflects investment of effort into the joint action. This predicts that participants would charge the adaptive partners batteries more than the unadaptive partners batteries, but only when they believed their partner could not adapt. Alternatively, decision-making coordination may foster commitment because aligning choices may act as a cue that our co-actor has similar beliefs or preferences to us, perhaps because decision-making coordination indicates similarity at the level of more stable features (e.g. in personality traits or worldview) compared to movement timing. This predicts that participants would charge the adaptive partners battery more than the unadaptive partners battery, regardless of their belief about the ability to adapt.

*As* in Experiment 1, to investigate the extent to which participants’ invested effort to charge their partners’ batteries, we conducted a 2x2 mixed ANOVA with partner (adaptive, unadaptive) as a within subjects factor, and belief (bidirectional, unidirectional) as a between subjects factor. The ANOVA revealed a significant main effect of partner, F(1,50) = 11.895, p < .001 ,$ = .172, but no significant main effect of belief, F(1,50) = .18, p = .67, $ = .004. However, there was a significant interaction between partner and belief, F(1,50) = 7.188, p = .01, $ = .104 (see figure 3), with participants investing more effort to earn points for the adaptive partner than the unadaptive partner, but only in the bidirectional belief condition, t(25) = 3.609, p = .001, d = .708, and not in the unidirectional condition, t(25) = .73, p = .47, d = .14. This result generalizes our findings from Experiment 1, demonstrating that as well as adaptation of movement timing when coordinating actions, adaptation of choices when trying to coordinate decisions can also foster commitment. Rather than just happening to have the same choices or preferences as someone, adaptation provides evidence that our partner is willing to invest effort by considering our perspective and adapting their decisions accordingly.

A LMM with partner and belief as fixed effects and trial as a random effect revealed a significant effect of partner, z=-5.41, p < .001, and no effect of belief, z = -1.128, p = .259. Even when we controlled for trial there was still an interaction between direction and knowledge, z = 4.043, p < .001, showing that our effects cannot be explained due to differences in fatigue or motivation.

*Ruling out similarity*

As in Experiment 1 with asynchrony, in this experiment the coordination accuracy was an index of similarity, because coordination success relies on the participant and partner making the same choices. On the accuracy data, we carried out a 2 x 2 mixed ANOVA, with partner as a within subjects factor and belief as a between subjects factor. This analysis revealed a main effect of partner, F(1,50) = 47.15, p < .001, $ = .48, but no main effect of belief, F(1.50) = .057, p = .812, $ = .001. There was also no interaction between partner and belief, F(1,50) = 0.97, p = .327, $ = .01 (see figure 4), suggesting that our manipulation did not lead to between group differences in decision based similarity. A LMM with partner and belief as fixed factors, and coordination accuracy as a random factor revealed a significant effect of partner, z=-3.366 ,p < .001, but no effect of belief, z = -1.204, p = .228. However, even with the variability associated with coordination accuracy controlled for, the interaction between partner and belief was still significant, z = 2.619, p = .009. These findings provide evidence that our findings cannot be explained simply by similarity of choices, but rather by adaptation of choices in consideration of our partners’ perspective. Like in Experiment 1, this finding also rules out coordination success as a potential explanation, as this would predict that participants would be more committed to the adaptive partner due to more successful coordination, regardless of belief about ability to adapt.

**General discussion**

Commitment is a glue holding characteristically human forms of social life together. When people are committed to a joint action partner or to a group, they are willing to invest time and effort to benefit that partner or that group. In some instances, this even requires them to persist in boring or difficult tasks, or to forego attractive opportunities which may benefit them more in the short term. In the long run, however, these sacrifices are dwarfed by the benefits arising from stable relationships, groups and institutions. This study aimed to investigate which features of coordinated social interactions lead people to develop sense of commitment towards their co-actor. Across two experiments, we demonstrate that a co-actor’s adaptation of movements or decisions in order to ensure successful and smooth coordination fosters a sense of commitment towards that co-actor.

Crucially the effects of coordination upon commitment which we observed cannot be fully explained by the hypothesis that coordination provides a cue to perceived interpersonal similarity. This is because, though we did observe a main effect of similarity in both experiments, the interaction between Partner and Belief conditions reveals that the boost which successful coordination gave to commitment was driven in part by the inferences participants were able to draw about their partners’ willingness to adapt. This means that our findings support the hypothesis that coordination boosts commitment by providing a evidence of a co-actor’s willingness to invest effort in order to adapt for the sake of coordination. It is also important to highlight the generalizability of this finding, which we observed in two highly distinct scenarios: one involving a task that required physical effort to adapt, and one involving a task that required cognitive effort to adapt.

These findings constitute an important contribution to our understanding of what it is that sustains people’s motivation to invest and make sacrifices for each other, and for the common good, both on a small and on a large scale. This is particularly pressing in the face of global challenges such as those posed by pandemics and climate change, which require the sustained and concerted commitment of everyone -- not just of the nurses, doctors, soldiers and teachers whose selfless contributions we so often take for granted.

Our findings also provide a springboard for further research investigating the mechanisms which lead people to develop a sense of commitment towards adaptive co-actors. One hypothesis is that, by investing the effort required to adapt, a co-actor signals that she is a reliable interaction partner, and that it is therefore worth cultivating a collaborative relationship with her. This would explain why participants were particularly willing to invest effort to benefit partners who had demonstrated a willingness to adapt. A further, compatible, hypothesis is that a co-actor’s investment of effort creates a sense of debt or obligation towards that co-actor, leading to an increase in effort to ‘repay one’s debt’ to the co-actor (McGrath & Gerber, 2019). Further research could attempt to disentangle these two hypotheses by implementing one or both of the tasks developed for the current study, and subsequently administering economic games tapping into distinct prosocial motivations For example, if our manipulation leads participants to view the adaptive partner as more reliable or trustworthy than the unadaptive partner, then they should be willing to invest more in a trust game with the an adaptive partner more than with the unadaptive partner (Berg, Dickhaut, & McCabe, 1995). Alternatively, insofar as participants feel a sense of debt towards the adaptive partner, then they may be expected to give more to the adaptive partner than the unadaptive partner in a dictator game (Güth, Schmittberger, & Schwarze, 1982).