When Driving Hurts: Characterizing the experience and impact of driving with back pain

Seward, Joshua[1], BS, Stavrinos, Despina[1], PhD, Moore, David[2,3], PhD, Attridge, Nina[4], PhD, Trost, Zina[5], PhD

1 Department of Psychology, University of Alabama at Birmingham, USA
2 School of Natural Sciences and Psychology, Liverpool John Moores University, UK
3 Research Centre for Brain and Behaviour, Liverpool John Moores University, UK
4 School of Science, Loughborough University, UK
5 Virginia Commonwealth University, USA

Corresponding author: Joshua Seward, Department of Psychology, University of Alabama at Birmingham, Birmingham, Al, USA; Tel: (334) 313-3216; Email: jseward@crimson.ua.edu

Original Article

Significance: Research acknowledges the inherent association between pain and attention. The current paper provides an initial examination of the role of attention and pain in the context of driving – a common activity that likewise demands attention.

1. INTRODUCTION

Driving is considered an instrumental activity of daily living (1). Driving is likewise an active process requiring cognitive functions such as perception, decision-making, and attention (2–4). Studies across multiple domains have reliably demonstrated that pain "demands attention" (5–8) and can negatively impact performance on tasks that require attentional control (9). Accordingly, a growing body of research has examined the interface between driving and pain experience (3,4,10–13). In general, both lab (4,14) and field studies (13) have found deficits in driving performance across such conditions as fibromyalgia (11,15), whiplash (3,4,16), and other chronic non-malignant pain conditions (13,14). Collectively, these findings suggest that the experience of driving in pain is a relatively common phenomenon that deserves further empirical scrutiny.

Low back pain is a leading cause of pain and disability in the United States (17,18), as well as one of the most common reasons for work days lost (19,20). Individuals with chronic low back pain (CLBP) report significant impairment across domains of daily living, including family, social, and workplace function (21–23), as well as significant psychological distress (24–28). Studies find that over 60% of long haul delivery drivers (29), taxi drivers (30), and bus drivers (12) experience CLBP. While these studies focus on the physical/musculoskeletal repercussions of long driving hours (12,29–32), to date, very few studies have examined the potential *impact of CLBP on driving experience*, including that of non-professional drivers. For example, Hu et al., (33) used epidemiological data from Department of Motor Vehicles (DMV) records to identify back pain as a potential crash risk factor in older women (but not men). Another study reported that back pain was significantly associated with a collision history in truck drivers, which the authors attributed to potential distraction stemming from pain as well as a limited range of movement (34).

In summary, despite the ubiquity of both driving and CLBP, almost no studies to date have characterized the experience of driving with CLBP. Further, no studies have examined the association between driving with pain and key cognitive-psychosocial predictors of pain experience. In particular, pain catastrophizing, defined as an exaggerated negative orientation toward pain (35), has been associated with worse physical and psychological outcomes in CLBP (36), as well as with greater difficulties in performing cognitive tasks while in pain (37). Of particular interest to the current study, catastrophizing has been associated with attentional capture by pain (7,38) and most recently with cognitive intrusion by pain (5,7,38); the latter was assessed by the Cognitive Intrusion of Pain Scale (ECIP) (5), developed to measure cognitive/attentional interruption by an endogenous or exogenous pain stimulus.

The current study represents a preliminary cross-sectional investigation of self-reported driving experience in a sample of individuals with CLBP, focusing on the experience of pain, affective response (specifically fear, anxiety, and irritation), and self-reported driving behavior and outcomes. The current descriptive findings are intended to serve as a foundation for more future, causally oriented research. We predicted that pain experience, affective responses, pain catastrophizing and the cognitive intrusion by pain would have positive associations not only amongst each other, but also with risky driving behaviors and poor driving outcomes.

2. MATERIALS AND METHODS

2.1 Participants

Participants were recruited from the United States using Mechanical Turk (MTurk), which is an online marketplace that allows people to post their study to a job board that is accessible by people with an MTurk worker account. MTurk is commonly utilized in epidemiological and

psychological research to collect data from the general population (39). Studies of MTurk responses have been found to retain a satisfactory level of internal and test-retest reliability, and have prevalence rates of clinical symptoms matching the general population (40,41). The MTurk job listing invited participants to complete a paid 60-minute Qualtrics questionnaire pertaining to chronic back pain and driving. Interested participants were screened for if they had recurring back pain (minimum 3 months, with more than half the days in the past 6 months) and have driven a vehicle in the past week. If participants did not pass the screening process, they were excluded from the survey and had their IP addresses blocked from being able to retake the survey. Qualitative questions were provided throughout the survey to both provide better insight into participant pain and driving experience and serve as an additional check for inattentive responses (i.e. impossible to achieve weekly driving hours, greater duration of pain than age, etc.). Participants gave informed consent before being screened for eligibility and were compensated $2.00 upon completion of the survey. This study was reviewed and approved by the University Institutional Review Board (IRB) at the University of Alabama in Birmingham (UAB).

2.2 Measures

2.2.1 Demographic Characteristics and Driving History

Demographic information was collected in accordance with the minimum dataset for CLBP (18), including participants' gender, age, income, education, and race. Participants reported the average number of hours spent driving a vehicle each week. Additionally, participants reported the total number of vehicle collisions (where they were the driver) within the last 3 years.

2.2.2 Pain Characteristics

Average low back pain intensity over the past seven days was assessed using a single item on a ten-point scale ranging from 1 (no pain) to 10 (worst imaginable pain) (18). Participants were also asked to indicate the duration of their back pain.

The Pain Disability Index (PDI) (42) was used to measure the degree to which participants perceived that chronic pain typically disrupted aspects of their daily life across 7 different domains: home, social, recreational, occupational, sexual, self-care, and life support activities (e.g., sleeping and eating). Each domain was scored on an 11-point scale ranging from 0 (no disability) to 10 (worst disability). Scores could range from 0 to 70, with higher scores signifying greater perceived disability as a result of chronic pain. A Cronbach's alpha score of .89 indicated high internal consistency.

Participants were also asked to indicate how often they utilized opiate pain medications (e.g., Vicodin, Lortab, Norco, hydrocodone, codeine, Tylenol #3 or #4, Fentanyl, Duragesic, MS Contin, Percocet, Tylox, OxyContin, oxycodone, methadone, tramadol, Ultram, Dilaudid) using a 7-point scale including the items 1 (Never), 2 (Once every few months), 3 (About once a month), 4 (A few times a month), 5 (About once per week), 6 (A few times per week), and 7 (Every day).

2.2.4. Cognitive-Characteristics

The Pain Catastrophizing Scale (PCS)(35) was used to measure a heightened negative orientation towards pain which included the tendency to magnify, ruminate on, and feel helpless in the presence of pain. Participants were presented with 13 items that characterized various thoughts or feelings about the pain experience and were asked to indicate the degree to which they experienced these feelings using a 5-point scale ranging from 0 (not at all) to 4 (all the time). PCS scores range from 0 to 52, with higher scores indicating a higher degree of pain catastrophizing. A Cronbach's alpha score of .95 indicated high internal consistency.

The Experience of Cognitive Intrusion of Pain Scale (ECIP) (5) was modified for a driving context and used to measure the degree to which pain interrupts or dominates participants'

cognition and attention whenever they drive in pain. Participants were presented with 10 items that described various cognitive interruptions as a result of pain while driving and were asked to indicate how much each statement applied to them using a 7-point scale ranging from 0 (does not apply to me at all) to 6 (applies to me a lot). ECIP scores could range from 0 to 60 with higher scores indicating a greater instance of cognitive intrusion by pain while driving. A Cronbach's alpha score of .97 indicated high internal consistency.

2.2.5. Pain While Driving

A single item indicating the degree to which participants experience pain while they drive was assessed using a 7-point scale ranging from 0 (does not apply to me at all) to 6 (applies to me a lot). Similarly, a single item assessed the degree to which participants' pain was made worse by driving was scored using a 7-point scale ranging from 0 (does not apply to me at all) to 6 (applies to me a lot).

Participants were also asked to indicate how often they take pain medications, opiates not specified, while driving. This was a single question on a 4-point scale ranging from 1 (Never) to 4 (Always).

2.2.6. Affective Responses to Driving in Pain

Participant affective responses to driving in pain were assessed using 3 items on a 0 (not at all) to 10 (extremely) scale; items included *irritable, anxious,* and *afraid.* Participants were also asked to indicate both the degree to which they experienced irritability at other drivers and other passengers in the car as a result of their pain using 2 items on a 7-point scale ranging from 0 (does not apply to me at all) to 6 (applies to me a lot).

2.2.7. Driving Behavior

The Driving Behavior Questionnaire (DBQ) (43) is well-validated and widely used measure within transportation research; the DBQ was used to measure the frequency with which participants commit violations or make driving errors using 19 items on a 6-point scale ranging from 0 (never) to 5 (nearly all the time). DBQ items provided specific instances of driving violations and bad driving behavior, such as using the right lane to pass drivers due to impatience and tailgating slower vehicles to make them go faster. DBQ scores range from 0 to 95 with higher scores indicating worse driving behavior. A Cronbach's alpha score of .96 indicated high internal consistency.

The 9-item avoidance subscale of the Driving Habits Questionnaire (DHQ) (44) was used to measure the frequency with which participants avoid various driving situations in the past three months on a 5-point scale ranging from 0 (never) to 4 (always). DHQ scores range from 0 to 36 with higher scores indicating more avoidance habits while driving. A Cronbach alpha score of .84 indicated high internal consistency.

A single item measured the frequency with which participants let others drive when they are in pain on a 4-point scale ranging from 1 (never) to 4 (always).

2.3 Analytic plan

All analyses were conducted using SPSS Version 25. Means and standard deviations were reported for all study variables after checking for potential outliers. Univariate Analyses of Variance (ANOVAs) examined potential differences between male and female participants. Correlational analyses examined bivariate relationships between study measures assessing relevant demographic, pain, cognitive, affective, and driving behavior variables. Partial correlations were run between study measures after controlling for opioid use and pain duration. One-way ANOVAs examined differences across demographic, pain, cognitive, affective, and driving behavior variables for individuals who reported 0 or 1 or more collisions in the past three

years. Additional one-way ANOVAs were performed after specifically controlling for participants who had reported CLBP for at least three years. To reduce the likelihood of type I error we adjusted the alpha level in this research to .01.

3. RESULTS

3.1 Participant Demographic Characteristics

Participant demographic information and key count variables are summarized in Table 1. Of the 435 participants who accessed the survey, a total of 315 participants qualified via the screener questions and completed the study. After examining the qualitative questions provided throughout the survey, an additional 8 participants were omitted for providing inattentive responses, leaving 307 total participants (157 female). Of the participant sample, 237 (77.2%) identified as White, and the duration of back pain ranged from 4 months to 45 years (M=6.29, SD=6.63). Participants reported driving an average of 8.06 hours per week (SD = 6.41), similar to recent national estimates among average U.S. drivers (45). Of 307 participants, 53 (17.5%) reported having been involved in at least one collision over the past three years. Male participants reported significantly more hours spent driving per week than did female participants ($F(1, 302) = 7.73$, $p < .01$). These gender differences as well as the number of collisions observed in the sample are similar to other driving studies with samples similar in age and gender distributions (46–48).

3.2 Pain and Psychological Characteristics

Means and standard deviations for participants' pain intensity (M=5.63, SD=1.51) and pain-related disability (M=27.89, SD=13.63) appear in Table 2 along with other study variables detailed below. Score means fell within the expected range of values found in prior publications on CLBP (49–52). Of the sample, 42.2% (n=129) reported never consuming opiate medications. Relative to male participants, female participants reported greater disability associated with pain ($F(1, 304) = 4.01$, $p < .05$). Male participants reported a somewhat higher frequency of opioid use relative to female participants ($F(1, 304) = 3.93$, $p < .05$).

Participants' mean pain catastrophizing scores (M=20.76, SD=11.39) and ECIP-Driving scores (M=23.81, SD=15.07) are listed in Table 2. As noted, for the purposes of the current study, the instructions of the ECIP were modified to reflect cognitive intrusion of pain in the driving context; scores ranged widely from 0-60 and were of magnitude and distribution commensurate with previous studies (5,53).

3.3 Pain and Affective Responses While Driving

Participants' ratings of pain while driving and affective responses when driving in pain are summarized in Table 2. Almost all participants indicated some agreement with the statement "I have pain when I drive", with a little more than half the sample (i.e., 53.7%, n=164) endorsing substantial agreement (i.e., >3 on a 0 to 6 scale). Similarly, the majority of participants endorsed that driving makes their back pain worse, with 61.3% (n=187) indicating substantial agreement.

In terms of irritability when driving in pain, participant endorsement was distributed across the response options, with 6-13% of participants indicating agreement with each response item; 6.6% (n=20) of participants did not endorse irritability and 43.2% endorsed substantial agreement ($\geq$6 on a 0 to 10 scale). A similar distributed pattern was observed for items addressing irritability at other passengers and drivers, respectively, with more participants endorsing some irritability at other drivers (n=274) versus other passengers in the car (n=261).

While most participants reported some anxiety and fear when driving in pain, 20.3% (n=62) endorsed no anxiety experience and 55.3% (n=169) endorsed scores below 5 (on a 0 to 10 scale).

Likewise, 43.3% of the sample (n=132) denied feeling afraid when driving in pain and 77.7% scored below 5.

3.4 Driving Behavior

Contrary to prior research, (54), male participants reported higher DBQ scores relative to female participants, indicating more errors and violations when driving ($F(1, 301) = 14.74$, $p = .00$). Women reported greater driving avoidance versus men ($F(1, 301) = 20.24$, $p = .00$), and reported being more likely to let others drive when they are in pain ($F(1, 302) = 10.73$, $p < .001$).

3.5 Bivariate Correlations Among Study Variables

Table 3 shows bivariate correlations between study variables, which are color-blocked in order of magnitude to facilitate ease of interpretation only if their statistical significance reached the .01 alpha level criterion. Self-reported pain intensity showed a strong positive correlation with pain while driving ($r = 0.41$, $p < .01$). A moderate positive association was observed between pain intensity and pain exacerbation while driving ($r = .29$, $p < .01$), and irritability when driving in pain ($r = .21$, $p < .01$). Additionally, pain intensity was moderately positively associated with participants' PCS ($r = .26$, $p < .01$) and ECIP scores ($r = .29$, $p < .01$). Self-reported disability likewise showed moderate to strong positive associations with all study variables, including DBQ scores and DHQ-avoidance scores. Self-reported disability was also positively associated with frequency of utilizing pain medication when driving.

Pain catastrophizing and attentional capture by pain when driving (PCS and ECIP scores) were highly positively correlated; while both showed positive correlations with pain ($r = .35$ and $r = .39$, $p < .01$) and pain exacerbation ($r = .37$ and $r = .41$, $p < .01$) when driving. In terms of driving behavior, higher PCS and ECIP scores were associated with greater DBQ scores ($r = .34$ and $r = .34$, $p < .01$). PCS showed a higher correlation than ECIP scores with DHQ avoidance behavior and letting others drive when in pain. Both PCS and ECIP scores showed a small-moderate correlation with frequency of opioid utilization and small-moderate associations with utilization of pain medication while driving.

Higher pain intensity while driving was strongly associated with exacerbation of pain when driving; both showed moderate to strong positive associations to affective responses, in particular irritability at other drivers and passengers when in pain, respectively. Both likewise showed a small-moderate correlation with DHQ avoidant driving responses and taking medication while driving.

Affective responses (i.e. irritability, anxiety, and fear) while driving were all strongly associated with each other and showed small-moderate positive associations with DBQ (excluding irritability, $r = .26$, and $r = .39$, $p < .01$) and DHQ avoidance scores ($r = .22$, $r = .36$, and $r = .26$, $p < .01$), respectively. Likewise, small to moderate associations were observed between anxiety and fear responses while driving in pain and letting others drive while in pain and taking pain medication while driving. Finally, a moderate-strong positive association was observed between DBQ scores and the use of pain medication while driving ($r = .42$, $p < .01$). Notably, DBQ scores likewise showed a small positive association with frequency of opioid use ($r = .21$, $p < .01$).

3.6 Partial Correlations Among Study Variables

Partial correlations were performed to control for opioid use and pain duration. Following these analyses, the following associations were no longer statistically significant: pain intensity and letting others drive when experiencing pain ($r = .08$, $p = .19$) and irritability while driving in pain and DBQ scores ($r = .09$, $p = .12$). Associations between taking pain medications while driving and a number of different variables were also no longer statistically significant even at the .05 alpha level, including: irritability ($r = .06$, $p = .34$), anxiety ($r = .05$, $p = .36$), irritability at

other drivers while driving in pain (r = .07, p = .23), and letting other people drive while in pain (r = .05, p = .41). These changes are noted in Table 3; however, the majority of the observed correlations before controlling for these variables remained relatively unchanged in statistical significance afterwards.

3.7 Collision History

Table 2 shows means and standard deviations across study measures for individuals with and without recent collision history in the past 3 years. Analyses revealed several significant differences. In comparison to participants with no collision history, those who reported a history of collisions reported higher PCS scores (F(1, 303) = 8.46, p < .01) and higher attentional capture by pain when driving (i.e., ECIP-Driving scores); (F(1, 303) = 7.73, p < .01). Additionally, participants who endorsed a collision history reported greater irritability at other passengers and other drivers when driving in pain -- (F(1, 303) = 9.77, p < .01) and (F(1, 303) = 5.12, p < .05), respectively. Participants with a collision history also reported higher DBQ scores (F(1, 301) = 12.52, p <.001) and higher DHQ-Avoidance scores (F(1, 301) = 4.60, p < .05) than participants who did not endorse a collision history. Finally, participants with a positive collision history were younger than those with a negative collision history; (F(1, 305) = 7.80, p < .01).

The supplementary Table 2 shows that when correcting for participants who have experienced CLBP for a minimum of three years, changes to significance were observed in all previous relationships except for collision history on DBQ scores (F(1, 203) = 5.18, p < .05). However, despite the lack of statistical significance, means for PCS and ECIP scores were noticeably higher in the collision group (M = 23.30, SD = 13.35; M = 26.59, SD = 17.30) than in the non-collision group (M = 20.36, SD = 11.35; M = 23.00, SD = 15.00), respectively.

4. DISCUSSION

To our knowledge, the current study is the first to characterize driving experience specifically among individuals with CLBP, with attention to the relationship among key sensory, affective, and cognitive psychological metrics as well as self-reported driving history and behavior. Broadly, findings suggest that drivers with CLBP experience a wide range of somatic and affective responses. Indeed, over half of our participants reported experiencing pain when they drive, and the majority reported driving to be a source of increased pain intensity. Further, participants reported that pain while driving resulted in substantial irritation at both passengers and other drivers on the road. In line with studies of other pain conditions (e.g., whiplash, fibromyalgia, (3,11,15,16)), these data suggest that driving may be a significant source of pain and distress among many individuals with CLBP.

Surprisingly, the current study is the first to assess participants' affective response to driving in pain, and the first to address anger/irritation in the context of pain and driving. The relationship between anger and pain has been well-documented in the literature (55–60), as has the relationship between anger and driving (61–65). In the context of pain and disability, studies link anger with negative physical, social, and functional outcomes (58,60,66). Studies also reliably implicate anger and irritation in negative driving outcomes, including more fines, traffic violations, accidents, and aggressive driving behaviors (63,65). In partial support of the above associations, CLBP participants who reported a recent history of collisions while driving likewise reported higher irritation with other passengers and other drivers when driving in pain (note: before controlling for CLBP duration). It is important here to note that pain severity did not relate to the number of collisions; rather, the data points to the importance of psychological factors while driving with pain. While participants did not generally report substantial levels of fear/anxiety

when driving in pain, suggesting overall confidence on the road, a substantial portion of the sample reported avoiding driving or letting others drive when in pain.

Of particular interest in the current study were associations observed between participants' ECIP-Driving and PCS scores with pain, affective, and driving variables. In the current study, the ECIP was used to assess the extent to which pain interrupts or dominates participants' attention when they drive (5). Echoing previous findings (6,38) higher scores of attentional capture by pain and pain catastrophizing were consistently associated with elevated pain and negative affective responses in the driving context. Further, elevated ECIP-Driving and PCS scores were associated with more self-reported unsafe driving behaviors (driving errors and violations) and greater likelihood of a having had a collision; this effect remained even after adjusting for CLBP duration. These findings should be considered in the context of an established body of evidence that pain (including back pain) contributes to impaired performance on a variety of attentional tasks (67–72), and that self-reported cognitive intrusion by pain predicts worse performance on tasks designed to mimic real world challenges (6,7). Further, pain catastrophizing is generally associated with greater pain hypervigilance and difficulty disengaging from pain-related stimuli (37).

To date, very few studies have examined attentional function in the context of driving with pain. Studies of drivers with whiplash disorders found self-report of reduced concentration/ attention when driving (3,16). Three studies failed to find laboratory-assessed differences in attention-related functions between healthy controls and participants with pain, including mixed pain (13), fibromyalgia (15), and whiplash (4) samples. At the same time, all studies identified performative driving deficits (e.g., greater weaving, worse coordination) among participants with pain (4,13,15). While the current study did not compare participants to healthy controls, our results suggest that, in addition to standard tests of attention, it would be useful to assess the relative attentional toll of pain among drivers with painful conditions, and that this may provide a more nuanced understanding of driving-related findings. Further, although chronic pain patients have been shown to perform poorly on a range of neurocognitive tasks, these have generally been tasks performed for brief periods of time and which are novel to participants. Driving by comparison is a highly automated process which may therefore show differing relationships between pain and cognitive processing.

It is important to note that participants with CLBP in our sample did not report higher frequency of crashes compared to prior work with comparable samples. Although prior studies have identified driving performance deficits in specific pain populations (4,13), and have even drawn association between back pain and vehicle collisions (34), *the current findings do not suggest that CLBP is a risk factor for poor driving outcomes.* Rather, our study is the first to link common psychological phenotypes among individuals with CLBP (34) with a number of problematic driving-related outcomes. Given the prevalence of CLBP in the general population (17,18) and in professional drivers (12,29,30), the current study provides a foundation for efforts to better understand the mechanisms involved in driving behaviors of those with CLBP as well as the relationship between key cognitive-affective, attentional, and behavioral factors identified in the current study.

While research examining the direct effects of pain on driving performance is currently quite limited, considerable research has examined the effects of analgesic medication, in particular opioids, on driving outcomes (2,73–79). In addition to cognitive and attentional impairments (79), opioids are also related to various driving outcomes, such as collisions (80–82), longer reaction times (83), and trouble maintaining attention behind the wheel (79). Although medication use was not the focus of the current study, sample responses to items related to medication use while

driving are worthy of note. Approximately half the sample reported some opioid use and about half reported taking pain medication while driving. More frequent use of medication while driving showed some association with pain intensity, negative affective responses, and attentional capture by pain, as well as more driving errors and violations. Additionally, when controlling for opioid use and pain duration, taking medication while driving was no longer significantly associated with irritability and anxiety while driving in pain as well as letting others drive when in pain. Given extensive inquiry regarding risky/illegal driving behavior, the current study chose not to ask specifically regarding opiate use while driving, choosing to remain more general with respect to medication use. However, given that associations between medication use while driving and some affective responses were no longer statistically significant, there could possibly be a chance that this change was observed because opiates were the medication of choice taken while driving. This question remains pertinent for further study. Further, no causal claims or direction can be asserted regarding medication use and the above outcomes. Rather, combined with self-imposed driving restrictions when in pain (above), our findings point to potentially varied attitudes toward driving and medication use among individuals with CLBP and should be explored in future research.

A clear strength of the current study is that we were able to recruit a representative group of individuals with CLBP which allowed us to examine broad and basic questions with respect to pain during driving. However, the online nature of the data collection also represents a potential limitation, particularly as responses were self-report, with no objective assessment. As a result, responses are subject to potential negative biases (84) and socially desirable responding patterns (85), especially when discussing the possibility of poor driving performance. For example, while DBQ items provided instances of inappropriate driving actions, it is unclear whether participants recognized these as inappropriate or risky (e.g., texting and driving), or whether they even engaged in them. Another possible limitation is the overlapping time windows for study measures, which variably assessed pain-related responses during driving, in general, and in the span of the past week, thus potentially affecting observed correlations. Further, we cannot verify whether all participants reported back pain prior to collision, which was assessed over the past 3 years, and thus report supplementary results which limit the sample to individuals with at minimum 3 years of back pain. While overall relationships between variables do not change, observed loss of statistical significance (i.e., PCS and ECIP scores between individuals with and without collision history) suggest either a lack of power or key role of early injury in the relationship between collision and back pain. Further analysis revealed that PCS and ECIP scores in the collision group were substantially higher for those who had CLBP for less than 3 years than those who had experienced CLBP for more than 3 years, suggesting some sort of heightened awareness for these constructs for those with more recent onset of pain.

Although this study laid groundwork for research considering the role of psychological pain variables in driving performance, many of the results and questions posed in this study, including those suggested above, can more rigorously be addressed within an *experimental context*. For example, studies that actively compare the driving behavior between pain and non-pain groups, controlling strictly for duration of pain, are imperative to gaining a better grasp of the relationships suggested in this study. Possible avenues for objectively measuring participant driving behaviors have been discussed in the literature, with the main two methods being the use of an advanced driving simulator to monitor attentional control and responses to stressful events (2,4,14) or use of real world driving tests to measure the amount of vehicle swerving while on the road (2,13,78). Such studies can objectively capture participant attentional and behavioral performance without the potential bias of subject interpretation or reporting bias to self-report

questionnaires. Potentially, such experimental work can serve to validate or challenge paper-based responses.

Although causal interpretations cannot be drawn, there are clear clinical implications of the current descriptive findings. As noted above, driving is a critical activity for daily living, be it for attending work, maintaining social relationships, or attending medical appointments. As individuals in pain may have mobility issues which can impair walking or other modes of transport, driving may be even more crucial. The current findings reinforce multiple associations between pain and cognitive-affective variables that have been observed in literature outside the driving context, including pain intensity, anger, inattention, and behavioral disruption. Given that driving is a pervasive, potentially risky behavior that requires some form of cognitive focus and control, the current findings point to a continued need to examine these associations within this specific life context. As part of pain management approaches that facilitate high quality of life and participation, it may be important to consider strategies that address/mitigate pain and pain-related psychological responses behind the wheel, with potentially powerful implications for driving safety.

Conclusion

In conclusion, individuals with CLBP reported significant pain and distress during driving activity, suggesting that the experience of driving with back pain deserves more study and perhaps clinical consideration. Further, our findings suggest that key pain psychological variables, including pain catastrophizing and cognitive/attentional intrusion by pain while driving may be associated with negative emotional responses and problematic driving behavior. The current study is intended to provide a foundation for further scrutiny of this important subject.

Author Contributions

All authors made substantial contributions toward the overall design of the study as well as analyzing data, discussing the content of this manuscript, and reviewing the final draft.

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References

1. Occupational Therapy Practice Framework: Domain & Process 2nd Edition. Am J Occup Ther. 2008 Nov 1;62(6):625–83.

2. Ferreira DH, Boland JW, Phillips JL, Lam L, Currow DC. The impact of therapeutic opioid agonists on driving-related psychomotor skills assessed by a driving simulator or an on-road driving task: A systematic review. Palliat Med. 2018 Apr 1;32(4):786–803.

3. Takasaki H, Treleaven J, Johnston V, Jull G. Contributions of physical and cognitive impairments to self-reported driving difficulty in chronic whiplash-associated disorders. Spine. 2013 Aug 15;38(18):1554–60.

4. Takasaki H, Treleaven J, Johnston V, Rakotonirainy A, Haines A, Jull G. Assessment of driving-related performance in chronic whiplash using an advanced driving simulator. Accident Analysis & Prevention. 2013 Nov 1;60:5–14.

5. Attridge N, Crombez G, Van Ryckeghem D, Keogh E, Eccleston C. The Experience of Cognitive Intrusion of Pain: scale development and validation. Pain. 2015 Oct;156(10):1978–90.

6. Attridge N, Eccleston C, Noonan D, Wainwright E, Keogh E. Headache Impairs Attentional Performance: A Conceptual Replication and Extension. The Journal of Pain. 2017 Jan 1;18(1):29–41.

7. Moore DJ, Law AS. The disruptive effects of pain on multitasking in a virtual errands task. Scandinavian Journal of Pain. 2017;16(1):29–35.

8. Van Damme S, Crombez G, Eccleston C. Disengagement from pain: the role of catastrophic thinking about pain: Pain. 2004 Jan;107(1):70–6.

9. Van Ryckeghem DML, Crombez G, Goubert L, De Houwer J, Onraedt T, Van Damme S. The predictive value of attentional bias towards pain-related information in chronic pain patients: A diary study. PAIN®. 2013 Mar 1;154(3):468–75.

10. Fan A, Wilson KG, Acharya M, Cranney A, Buenger U, Marshall S. Self-Reported Issues With Driving in Patients With Chronic Pain. PM&R. 2012 Feb 1;4(2):87–95.

11. Fibromyalgia and the Risk of a Subsequent Motor Vehicle Crash | The Journal of Rheumatology [Internet]. [cited 2019 May 6]. Available from: http://www.jrheum.org/content/42/8/1502.short?casa_token=UQR23YpLIXMAAAAA:U_FF_6uLrQs2wJ69UIgEqaz5oX7U1KAhdJxkT2JRE7c1V2Swh8Tzgm2MMnG7lgByxaQqGBVCGg

12. Jadhav AV. Comparative cross-sectional study for understanding the burden of low back pain among public bus transport drivers. Indian J Occup Environ Med. 2016;20(1):26–30.

13. Veldhuijzen DS, van Wijck AJM, Wille F, Verster JC, Kenemans JL, Kalkman CJ, et al. Effect of chronic nonmalignant pain on highway driving performance: Pain. 2006 May;122(1):28–35.

14. Nilsen HK, Landrø NI, Kaasa S, Jenssen GD, Fayers P, Borchgrevink PC. Driving functions in a video simulator in chronic non-malignant pain patients using and not using codeine. European Journal of Pain. 2011 Apr 1;15(4):409–15.

15. Shmygalev S, Dagtekin O, Gerbershagen HJ, Marcus H, Jübner M, Sabatowski R, et al. Assessing Cognitive and Psychomotor Performance in Patients with Fibromyalgia Syndrome. Pain Ther. 2014 Dec;3(2):85–101.

16. Takasaki H, Johnston V, Treleaven J, Pereira M, Jull G. Driving With a Chronic Whiplash-Associated Disorder: A Review of Patients' Perspectives. Archives of Physical Medicine and Rehabilitation. 2011 Jan 1;92(1):106–10.

17. Courtney-Long EA, Carroll DD, Zhang QC, Stevens AC, Griffin S, Armour BS, et al. Prevalence of Disability and Disability Type Among Adults — United States, 2013. 2015;64(29):32.

18. Deyo RA, Dworkin SF, Amtmann D, Andersson G, Borenstein D, Carragee E, et al. Focus article report of the NIH task force on research standards for chronic low back pain. Clin J Pain. 2014;30(8):701–12.

19. Ricci JA, Stewart WF, Chee E, Leotta C, Foley K, Hochberg MC. Back Pain Exacerbations and Lost Productive Time Costs in United States Workers: Spine. 2006 Dec;31(26):3052–60.

20. Stewart WF, Ricci JA, Chee E, Morganstein D, Lipton R. Lost Productive Time and Cost Due to Common Pain Conditions in the US Workforce. JAMA. 2003 Nov 12;290(18):2443–54.

21. Garbi M de OSS, Hortense P, Gomez RRF, Silva T de CR da, Castanho ACF, Sousa FAEF, et al. Pain intensity, disability and depression in individuals with chronic back pain. Revista Latino-Americana de Enfermagem. 2014 Aug;22(4):569–75.

22. Stefane T, Santos AM dos, Marinovic A, Hortense P. Chronic low back pain: pain intensity, disability and quality of life. Acta Paulista de Enfermagem. 2013;26(1):14–20.

23. Strunin L, Boden LI. Family consequences of chronic back pain. Social Science & Medicine. 2004 Apr 1;58(7):1385–93.

24. Atkinson JH, Slater MA, Patterson TL, Grant I, Garfin SR. Prevalence, onset, and risk of psychiatric disorders in men with chronic low back pain: a controlled study. Pain. 1991 May 1;45(2):111–21.

25. Carroll LJ, Cassidy JD, Côté P. Depression as a risk factor for onset of an episode of troublesome neck and low back pain. Pain. 2004 Jan 1;107(1):134–9.

26. Currie SR, Wang J. Chronic back pain and major depression in the general Canadian population. Pain. 2004 Jan 1;107(1):54–60.

27. Currie SR, Wang J. More data on major depression as an antecedent risk factor for first onset of chronic back pain. Psychological Medicine. 2005 Sep;35(9):1275–82.

28. Krishnan KRR, France RD, Pelton S, McCann UD, Davidson J, Urban BJ. Chronic pain and depression. II. Symptoms of anxiety in chronic low back pain patients and their relationship to subtypes of depression. Pain. 1985 Jul 1;22(3):289–94.

29. Mozafari A, Vahedian M, Mohebi S, Najafi M. Work-related musculoskeletal disorders in truck drivers and official workers. Acta Med Iran. 2015 Jul;53(7):432–8.

30. Burgel BJ, Elshatarat RA. Psychosocial work factors and low back pain in taxi drivers. Am J Ind Med. 2017 Aug 1;60(8):734–46.

31. Kresal F, Roblek V, Jerman A, Meško M. Lower back pain and absenteeism among professional public transport drivers. International Journal of Occupational Safety and Ergonomics. 2015 Apr 3;21(2):166–72.

32. Mendelek F, Kheir RB, Caby I, Thevenon A, Pelayo P. On the quantitative relationships between individual/occupational risk factors and low back pain prevalence using nonparametric approaches. Joint Bone Spine. 2011 Dec 1;78(6):619–24.

33. Hu PS, Trumble DA, Foley DJ, Eberhard JW, Wallace RB. Crash risks of older drivers: a panel data analysis. Accident Analysis & Prevention. 1998 Sep 1;30(5):569–81.

34. Thiese MS, Ott U, Robbins R, Effiong A, Murtaugh M, Lemke MR, et al. Factors Associated With Truck Crashes in a Large Cross Section of Commercial Motor Vehicle Drivers: Journal of Occupational and Environmental Medicine. 2015 Oct;57(10):1098–106.

35. Sullivan MJL, Bishop SR, Pivik J. The Pain Catastrophizing Scale: Development and Validation. Psychological Assessment. 1995 Dec 1;7(4):524–32.

36. Alhowimel A, AlOtaibi M, Radford K, Coulson N. Psychosocial factors associated with change in pain and disability outcomes in chronic low back pain patients treated by physiotherapist: A systematic review. SAGE Open Medicine. 2018 Jan 1;6:2050312118757387.

37. Vancleef LMG, Peters ML. Pain catastrophizing, but not injury/illness sensitivity or anxiety sensitivity, enhances attentional interference by pain. J Pain. 2006 Jan;7(1):23–30.

38. Talaei-Khoei M, Ogink PT, Jha R, Ring D, Chen N, Vranceanu A-M. Cognitive intrusion of pain and catastrophic thinking independently explain interference of pain in the activities of daily living. Journal of Psychiatric Research. 2017 Aug 1;91:156–63.

39. Attridge N, Noonan D, Eccleston C, Keogh E. The disruptive effects of pain on n-back task performance in a large general population sample. Pain. 2015 Oct;156(10):1885–91.

40. Jaya ES, Hillmann TE, Reininger KM, Gollwitzer A, Lincoln TM. Loneliness and Psychotic Symptoms: The Mediating Role of Depression. Cogn Ther Res. 2017 Feb 1;41(1):106–16.

41. Shapiro DN, Chandler J, Mueller PA. Using Mechanical Turk to Study Clinical Populations: Clinical Psychological Science [Internet]. 2013 Jan 31 [cited 2020 Jun 24]; Available from: https://journals.sagepub.com/doi/10.1177/2167702612469015

42. Tait RC, Chibnall JT, Krause S. The Pain Disability Index: psychometric properties. Pain. 1990 Feb;40(2):171–82.

43. Reason J, Manstead A, Stradling S, Baxter J, Campbell K. Errors and violations on the roads: a real distinction? Ergonomics. 1990 Nov;33(10–11):1315–32.

44. Owsley C, Stalvey B, Wells J, Sloane ME. Older drivers and cataract: driving habits and crash risk. J Gerontol A Biol Sci Med Sci. 1999 Apr;54(4):M203-211.

45. American Driving Survey, 2014 – 2017 [Internet]. AAA Foundation. 2019 [cited 2019 May 24]. Available from: https://aaafoundation.org/american-driving-survey-2014-2017/

46. Donmez B, Mehler A, Lee J, Mehler B, Reimer B. The Relation Between the Driver Behavior Questionnaire, Demographics, and Driving History. In 2017.

47. Fatality Facts 2017: Gender [Internet]. IIHS-HLDI crash testing and highway safety. [cited 2019 Aug 13]. Available from: https://www.iihs.org/topics/fatality-statistics/detail/gender

48. Zhao N, Mehler B, Reimer B, D'Ambrosio LA, Mehler A, Coughlin JF. An investigation of the relationship between the driving behavior questionnaire and objective measures of highway driving behavior. Transportation Research Part F: Traffic Psychology and Behaviour. 2012 Nov 1;15(6):676–85.

49. Castro-Sánchez AM, Lara-Palomo IC, Matarán- Peñarrocha GA, Fernández-Sánchez M, Sánchez-Labraca N, Arroyo-Morales M. Kinesio Taping reduces disability and pain slightly in chronic non-specific low back pain: a randomised trial. Journal of Physiotherapy. 2012 Jun 1;58(2):89–95.

50. Grönblad M, Järvinen E, Hurri H, Hupli M, Karaharju EO. Relationship of the Pain Disability Index (PDI) and the Oswestry Disability Questionnaire (ODQ) with three dynamic physical tests in a group of patients with chronic low-back and leg pain. Clin J Pain. 1994 Sep;10(3):197–203.

51. Smeets RJEM, Vlaeyen JWS, Kester ADM, Knottnerus JA. Reduction of Pain Catastrophizing Mediates the Outcome of Both Physical and Cognitive-Behavioral Treatment in Chronic Low Back Pain. The Journal of Pain. 2006 Apr 1;7(4):261–71.

52. Soer R, Reneman MF, Vroomen PCAJ, Stegeman P, Coppes MH. Responsiveness and Minimal Clinically Important Change of the Pain Disability Index in Patients With Chronic Back Pain. Spine. 2012 Apr 15;37(8):711.

53. Turner JA, Anderson ML, Balderson BH, Cook AJ, Sherman KJ, Cherkin DC. Mindfulness-based stress reduction and cognitive-behavioral therapy for chronic low back pain: similar effects on mindfulness, catastrophizing, self-efficacy, and acceptance in a randomized controlled trial. Pain. 2016 Nov;157(11):2434–44.

54. de Winter JCF, Dodou D. The Driver Behaviour Questionnaire as a predictor of accidents: a meta-analysis. J Safety Res. 2010 Dec;41(6):463–70.

55. Berkowitz L. On the formation and regulation of anger and aggression. A cognitive-neoassociationistic analysis. Am Psychol. 1990 Apr;45(4):494–503.

56. Bruehl S, Burns JW, Chung OY, Chont M. Pain-related effects of trait anger expression: neural substrates and the role of endogenous opioid mechanisms. Neurosci Biobehav Rev. 2009 Mar;33(3):475–91.

57. Burns JW, Quartana P, Bruehl S. Anger Suppression and Subsequent Pain Behaviors among Chronic Low Back Pain Patients: Moderating Effects of Anger Regulation Style. Ann Behav Med. 2011 Aug;42(1):42–54.

58. Burns JW, Quartana PJ, Bruehl S. Anger inhibition and pain: conceptualizations, evidence and new directions. J Behav Med. 2008 Jun;31(3):259–79.

59. Fernandez E, Wasan A. The Anger of Pain Sufferers: Attributions to Agents and Appraisals of Wrongdoings. In: International Handbook of Anger [Internet]. Springer, New York, NY; 2010 [cited 2018 Mar 16]. p. 449–64. Available from: https://link.springer.com/chapter/10.1007/978-0-387-89676-2_26

60. Okifuji A, Turk DC, Curran SL. Anger in chronic pain: Investigations of anger targets and intensity. Journal of Psychosomatic Research. 1999 Jul 1;47(1):1–12.

61. Deffenbacher JL, Lynch RS, Oetting ER, Yingling DA. Driving anger: correlates and a test of state-trait theory. Personality and Individual Differences. 2001 Dec 1;31(8):1321–31.

62. Deffenbacher JL, Stephens AN, Sullman MJM. Driving anger as a psychological construct: Twenty years of research using the Driving Anger Scale. Transportation Research Part F: Traffic Psychology and Behaviour. 2016 Oct 1;42:236–47.

63. González-Iglesias B, Gómez-Fraguela JA, Luengo-Martín MÁ. Driving anger and traffic violations: Gender differences. Transportation Research Part F: Traffic Psychology and Behaviour. 2012 Jul 1;15(4):404–12.

64. Underwood G, Chapman P, Wright S, Crundall D. Anger while driving. Transportation Research Part F: Traffic Psychology and Behaviour. 1999 Mar 1;2(1):55–68.

65. Zhang T, Chan AHS. The association between driving anger and driving outcomes: A meta-analysis of evidence from the past twenty years. Accident Analysis & Prevention. 2016 May 1;90:50–62.

66. Greenwood KA, Thurston R, Rumble M, Waters SJ, Keefe FJ. Anger and persistent pain: current status and future directions. Pain. 2003 May;103(1–2):1–5.

67. Crombez G, Eccleston C, Baeyens F, Eelen P. Attentional disruption is enhanced by the threat of pain. Behav Res Ther. 1998 Feb;36(2):195–204.

68. Eccleston C, Crombez G. Pain demands attention: a cognitive-affective model of the interruptive function of pain. Psychol Bull. 1999 May;125(3):356–66.

69. Keogh E, Cavill R, Moore DJ, Eccleston C. The effects of menstrual-related pain on attentional interference. Pain. 2014 Apr;155(4):821–7.

70. Moore DJ, Keogh E, Eccleston C. Headache impairs attentional performance. Pain. 2013 Sep;154(9):1840–5.

71. Moore DJ, Keogh E, Eccleston C. The effect of threat on attentional interruption by pain. PAIN. 2013 Jan;154(1):82.

72. Moore DJ, Keogh E, Eccleston C. The interruptive effect of pain on attention. Q J Exp Psychol (Hove). 2012;65(3):565–86.

73. Dassanayake T, Michie P, Carter G, Jones A. Effects of benzodiazepines, antidepressants and opioids on driving: a systematic review and meta-analysis of epidemiological and experimental evidence. Drug Saf. 2011 Feb 1;34(2):125–56.

74. Duren M, Ehsani J, Grant B, Fowler D. Geographic variation and trends in opioid-involved crash deaths in Maryland: 2006–2017. Accident Analysis & Prevention. 2019 Apr 1;125:1–6.

75. Galski T, Williams JB, Ehle HT. Effects of Opioids on Driving Ability. Journal of Pain and Symptom Management. 2000 Mar 1;19(3):200–8.

76. Leung SY. Benzodiazepines, opioids and driving: an overview of the experimental research. Drug Alcohol Rev. 2011 May;30(3):281–6.

77. Li G, Chihuri S. Prescription opioids, alcohol and fatal motor vehicle crashes: a population-based case-control study. Injury Epidemiology. 2019 Mar 25;6(1):11.

78. Schumacher MB, Jongen S, Knoche A, Petzke F, Vuurman EF, Vollrath M, et al. Effect of chronic opioid therapy on actual driving performance in non-cancer pain patients. Psychopharmacology. 2017 Mar 1;234(6):989–99.

79. Strand MC, Vindenes V, Gjerde H, Mørland JG, Ramaekers JG. A clinical trial on the acute effects of methadone and buprenorphine on actual driving and cognitive function of healthy volunteers. British Journal of Clinical Pharmacology. 2019;85(2):442–53.

80. Bachs L, Engeland A, Mørland J, Skurtveit S. The Risk of Motor Vehicle Accidents Involving Drivers With Prescriptions for Codeine or Tramadol. Clin Pharmacol Ther. 2009 Jun;85(6):596–9.

81. Chihuri S, Li G. Use of Prescription Opioids and Initiation of Fatal 2-Vehicle Crashes. JAMA Netw Open. 2019 Feb 1;2(2):e188081–e188081.

82. Chihuri S, Li G. Use of prescription opioids and motor vehicle crashes: A meta analysis. Accident Analysis & Prevention. 2017 Dec 1;109:123–31.

83. Schindler S-D, Ortner R, Peternell A, Eder H, Opgenoorth E, Fischer G. Maintenance therapy with synthetic opioids and driving aptitude. Eur Addict Res. 2004;10(2):80–7.

84. Greve KW, Bianchini KJ. Setting empirical cut-offs on psychometric indicators of negative response bias: a methodological commentary with recommendations. Arch Clin Neuropsychol. 2004 Jun 1;19(4):533–41.

85. Mortel VD, F T. Faking It: Social Desirability Response Bias in Self-report Research. Australian Journal of Advanced Nursing, The. 2008 Aug;25(4):40.

86. da Silva T, Mills K, Brown BT, Pocovi N, de Campos T, Maher C, et al. Recurrence of low back pain is common: a prospective inception cohort study. Journal of Physiotherapy. 2019 Jul 1;65(3):159–65.